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THE PLANT DISEASE REPORTER

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AGRICULTURAL RESEARCH SERVICE

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The Plant Disease Reporter is issued as a service to plant pathologists throughout the United States. It contains reports, summaries, observations, and comments submitted voluntarily by qualified observers. These reports often are in the form of suggestions, queries, and opinions, frequently purely tentative, offered for consideration or discussion rather than as matters of established fact. In accepting and publishing this material the Plant Disease Epidemics and Identification Section serves merely as an informational clearing house. It does not assume responsibility for the subject matter.

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THE PLANT DISEASE REPORTER

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THE EPIDEMIOLOGY UNIT
PLANT DISEASE EPIDEMICS AND IDENTIFICATION SECTION

Horticultural Crops Research Branch — Plant Industry Station, Beltsville, Maryland
Volume 38 — September 15, 1954 — Number 9

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LATE BLIGHT OF POTATOES IN GUATEMALA[1]

F. J. LeBeau[2] and Eugenio Schieber[3]

Late blight of potato caused by Phytophthora infestans is probably the factor which most limits potato production in Guatemala. Because of low production the potato is costly and is consequently more of a luxury food than a basic food crop. Largely because of late blight cropping systems have become established which result in low production and widely varying prices.

Two systems of culture are usually employed: 1) A dry season culture in which planting is done at the end of the rainy season and the crop is produced on residual moisture and in some cases with irrigation. This system is characteristic of the department of Santa Rosa and surrounding areas at altitudes of 3000-5000 feet. Under these conditions late blight is of little or no importance. 2) An early spring culture in which potatoes are planted in February and harvested during the early part of the rainy season. This system is carried on in the western highlands at altitudes of 8000 to 11,000 feet. In this area late blight is of yearly occurrence but normally causes only small reductions in yield since the crop is practically made before conditions are favorable for disease development. Under both systems of culture conditions are unfavorable for maximum production largely because of inadequate moisture supply. Consequently yields are very low, the national average being about 50 bushels per acre[4].

In the extensive areas, between 6000 and 8000 feet elevation, of the western intermountain region of the country, potatoes are rarely produced either as a rainy season or a dry season crop. This region would appear to be well suited for potato production during the rainy season.

In 1951, during the rainy season, plantings were made at three stations: Chimaltenango, Tecpán, and Quezaltenango at 6000, 7000, and 7800 feet respectively, to explore the possibilities of potato production in these areas. Late blight developed so severely at each of the stations as to preclude potato production under those conditions. Susceptible varieties such as Bintje, Ari, and Saskia were killed completely within six to eight weeks of planting, and produced low yields (50-70 bushels per acre total) of small tubers. The varieties Alpha and Voran proved to be more resistant and produced higher yields (100-125 bushels per acre total) with only a fair percentage of U. S. #1 tubers. These observations suggested that it is because of the severity of late blight in those areas that no appreciable amounts of potatoes are produced.

In the spring of 1952 a number of additional varieties and unnamed seedlings were planted in an observation planting in Chimaltenango. The harvest from these were planted in Quezaltenango in the spring of 1953. In both years severe blight developed, the susceptible varieties succumbing completely to the disease within about two months of planting. Observations from these plantings are given in Table 2. The photographs in Figure 1 show the reactions of several varieties to the disease while Figure 2 shows the harvest from 25 hill-plots of some of these varieties.

Aside from the varieties listed in Table 1, several USDA clones furnished by the U. S. Department of Agriculture[5] were included. Because the exact identity of these were subject to question, they are not included in the table. However, several of them were highly resistant to the disease. It will be observed that the several varieties generally recognized as very susceptible were rapidly destroyed by the disease with correspondingly low yield of tubers. Several of the Dutch varieties and Sebago showed considerable resistance. These produced better yields but for the most part the percentage of U. S. #1 tubers was low. The varieties Cherokee, Kennebec, and Placid as well as some of the seedling clones were highly resistant (no study was made to determine if the few necrotic lesions which appeared on those near harvest time were due to P. infestans and therefore it cannot be said that they were immune) and produced relatively good yields with a high percentage of U. S. #1 tubers. It would seem therefore that since the varieties which carry the R1 gene for resistance to P. infestans have remained free from

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[1] Instituto Agropecuario Nacional, a cooperative Agricultural Experiment Station maintained and operated by the Republic of Guatemala through the Ministry of Agriculture, and the United States of America through the U. S. Department of Agriculture.

[2] Agriculturist - Research Advisor - Plant Pathology.

[3] Assistant, Department of Plant Pathology, Instituto Agropecuario Nacional.

[4] Data from the Agricultural Census of 1950.

[5] The writers are indebted to Dr. F. J. Stevenson, Agricultural Research Service, U. S. Department of Agriculture, for furnishing seed of several varieties and unnamed clones.

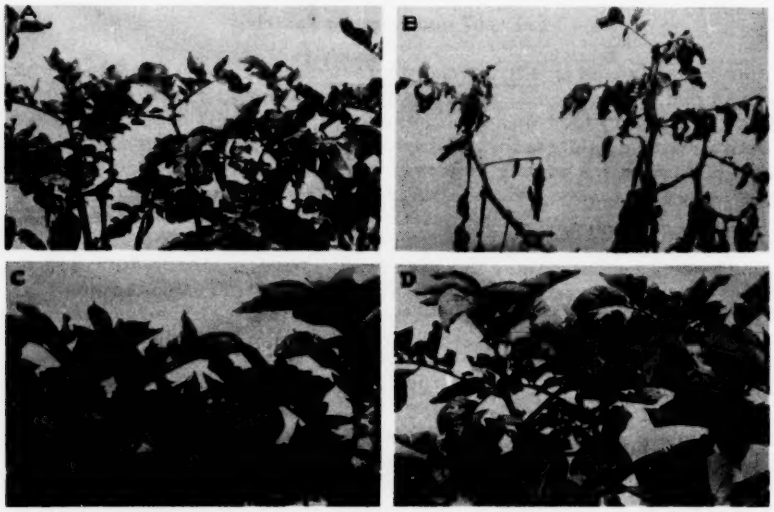

FIGURE 1. Reaction of potato varieties to Phytophthora infestans. A-- Profit; B -- Bintje; C -- Placid; D -- Cherokee.

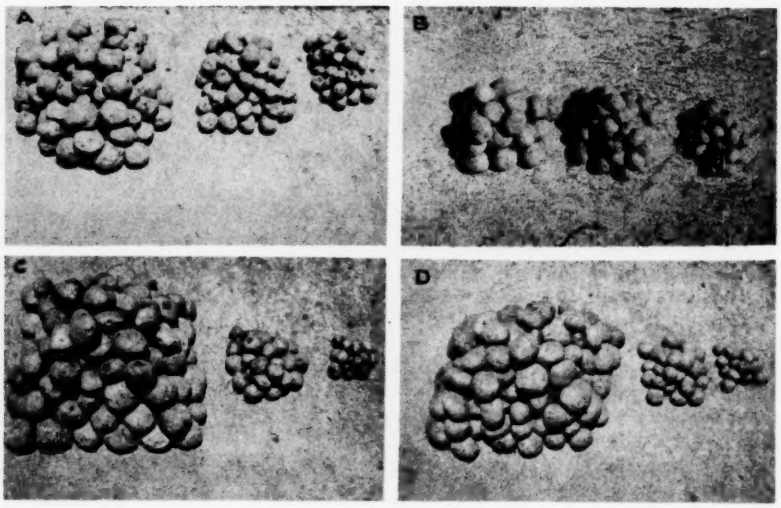

FIGURE 2. Tuber production from 25 hills each of four varieties of potato: A -- Profit; B -- Bintje; C -- Placid; D -- Cherokee.

Table 1. Reaction of several potato varieties to late blight caused by P. infestans in 1952 and 1953.

Variety	Chimaltenango 1952 Reaction to P. infestans	Quezaltenango 1953, planted April 29				
		P. infestans on[a]			Yield lbs./acre[c]	
		June 24	July 8	July 28	U.S. #1	Total
Alpha	Moderately resistant	T	2-3	3	10,040	15,780
Bintje	Susceptible	3	5	5	3,210	6,960
Cherokee	Highly resistant	0	0	0	19,740	21,510
Gineke	Moderately resistant	T	2	3	8,710	13,340
Ideal	Susceptible	2	5	5	[b]	
Katahdin	Susceptible	3	5	5	[b]	
Kennebec	Highly resistant	0	0	0	[b]	
Osterbrote	Moderately resistant	T	3-4	4	3,840	9,220
Placid	Highly resistant	0	0	0	18,390	21,360
Profit	Moderately resistant	T-1	3	4	9,680	14,920
Sebago	Moderately resistant	T	2	3	7,830	12,580
Up-to-date	Susceptible	3	5	5	860	5,040
Voran	Moderately resistant	T-1	2-3	3	4,290	10,660[d]
Native 1		0	1	2	[b]	
Native 2		T	1	3	2,020	5,180[d]
Native 3		0	1	1	[b]	
Native 4		T	1	2	7,840	15,350[d]
Native 5		1	5	5	[b]	

[a] T = Scattered infection. 0 = No apparent infection. 1-5 = general light infection (1) to dead (5). Where 2 values appear they represent the range between different plots.

[b] The amounts planted were inadequate to estimate yields.

[c] 1000 lbs. per acre of a 6-12-4 mixture was applied before planting.

[d] Harvested immature.

infection, that race #1 of the fungus was not present in the areas under study. The native varieties, with one exception, showed considerable resistance to the disease; none, however, with resistance equivalent to that of Cherokee, etc. They were for the most part late maturing varieties which produced large numbers of stems and with generally non-uniform tubers.

SUMMARY

Observation over a three year period has shown that late blight is a limiting factor in potato production in the highlands of Guatemala during the rainy season. That the local system of potato production is to a large extent determined by the prevalence of this disease is suggested.

Using resistant varieties, reasonably good yields (5 to 6 times the national average) have been obtained in rainy season plantings, a custom not usually practiced locally.

Varieties having the R1 gene have remained free from infection, indicating that race #1 is not prevalent in the areas under study.

INSTITUTO AGROPECUARIO NACIONAL

CANTALOUPE DOWNY MILDEW IN THE LOWER RIO GRANDE VALLEY OF TEXAS AND ITS RELATION TO RELATIVE HUMIDITY

G. H. Godfrey

Greater than average rainfall and accompanying high humidity occurred in the Lower Rio Grande Valley in the spring season of 1954, and downy mildew (Pseudoperonospora cubensis) again became a limiting factor in cantaloupe production. The three previous years had been dry and cantaloupe growers had attained a false sense of security because of freedom from downy mildew as a factor in production, and because of planting largely powdery mildew resistant varieties. This paper reports an attempt to analyze the main differences between weather conditions, particularly humidity, in 1954 and the immediately preceding years which might account for the abrupt change in the downy mildew picture. Unfortunately many growers were hurt by this change. A great many farmers, with land available because of the limitation placed upon cotton acreage, and influenced by the success of growers in previous years, planted the greatest acreage of record for this section.

Downy mildew was first found on the foggy morning of March 21 in a single field; and on March 28, with a repetition of foggy conditions, infection was present in threatening proportions in the same and neighboring fields. Warnings were issued at this time, and many growers began the application of fungicides even though the mildew was not yet general. There followed a rainy period, April 9 to 15 (total rainfall at the Experiment Station, 6.84 inches) when efficient fungicide applications could not be made, and in the next few days of high humidity infection became general throughout Valley plantings.

Thereafter new infections occurred throughout the balance of the season, apparently in light and heavy waves, depending upon moisture conditions. On low-lying infected leaves close to moist ground the sporulating fungus could be found any morning. During brief dry periods, diseased spots on higher leaves, with sharply delineated margins, did not develop sporangia. At such times new leaves on the rapidly growing plants remained free from infection for a period. In a very hot dry period some time after the week of high rainfall, a large proportion of the initially infected leaves died and became shrivelled, leaving fairly open vines with much healthy foliage showing. Had this condition persisted, many fields might have recovered sufficiently to produce a fair crop of good fruits. However, further periods of high humidity followed, and the disease continued to develop in spite of applications of fungicides. Some fields that received a rigorous four-day schedule of treatments remained greener than the average, and produced a good crop. The returns from many fields were less than the costs of production.

At the end of the season a detailed study was made of the weather records of the Weslaco Substation of the Texas Agricultural Experiment Station. The objective of this study was to try to single out the specific reasons why the 1954 season was so disastrous, as compared with the immediately preceding seasons. Attention became concentrated on the calculations of the 8:00 A.M. relative humidity. This decision was based on the known facts regarding the life history of the causal fungus, briefly: A continous film of moisture is required for the germination of sporangia with production of zoospores, the germination of zoospores, and the penetration of the leaf tissues, the whole process taking about four hours. Approximately four days is the incubation period required for a new infection to become manifest as a small yellow spot. Sporulation will begin shortly after, sometimes even before a brown area is to be seen in the middle of the infection lesion.

Conditions favorable to infection are prolonged periods of high air humidity, which may be brought about by rain, mist, or fog, or by heavy dew lasting well into the forenoon. A rather high humidity at 8:00 A.M. with much dew still manifest would indicate that conditions have probably been such that new infections might have occurred during the night. Conditions unfavorable to infection are dry days, absence of dews, or light dews drying off early in the morning because of a quick rise in temperature. A low relative humidity reading in the morning with little or no dew manifest would indicate that probably little or no new infection has occurred.

An 8:00 A.M. relative humidity reading of 86.5 percent is tentatively, as a basis for further discussion, considered to be approximately the dividing point above which new infections may have occurred during the night, and below which the plants may have escaped infection. The data given in the graph, Figure 1, show official 8:00 A.M. relative humidity calculations for the critical month of April, both in the bad downy mildew season of 1954 and in the 1953 season when downy mildew was not an economic factor in production. The curves are drawn between the daily 8:00 A.M. readings for both years. The 91.4 percent level, indicated by a light horizontal line, represents the average of all the April 1954 morning readings. A corresponding

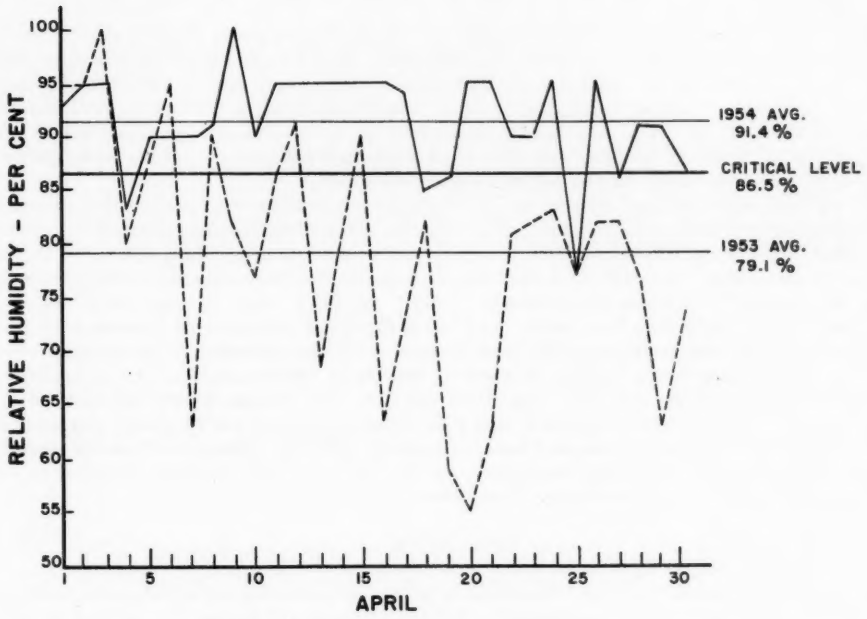

FIGURE 1. The relative humidity readings at the Weslaco, Texas Experimental Station at 8:00 A.M. for April, 1954 and for April, 1953, showing the great difference between the two years. The season of 1954 was a bad cantaloupe downy mildew season; 1953 was a non-downy mildew season.

line at the 79.1 percent level represents the average of the April 1953 readings. In addition a heavy black line is drawn at the 86.5 percent level to represent the critical level for infection referred to above.

The graph shows that the 1954 readings are higher than the 1953 readings through almost the entire month. The averages of the two sets of readings are 12.3 percentage points apart--enough of itself to account for a great deal of difference between the two seasons in the occurrence of new infections. The numbers of days in each case when morning humidity was above and below the critical level for infection may have even greater significance. In 1954 25 days had readings above the critical level with only 5 days below it. In 1953 only 7 days were above the critical level, and these were mostly widely separated as shown by the sharp points in the curves; 23 days were below the critical level.

A brief presentation comparing May readings for 1954 and 1953 also justifies consideration. In May 1954, in the midst of cantaloupe harvest, conditions continued to be favorable to downy mildew most of the time. The average of the 8:00 A.M. relative humidity for the month was 86.4 percent, which was almost exactly at the critical level for infection. This means that on half the days the morning readings indicated that conditions were favorable for infection and on the other half conditions were unfavorable. With a state of "saturation" with living infective material, heavy infections persisted, though actually occasional periods occurred when there was an apparent greening-up of the vines from healthy new leaf growth. In May 1953 the average morning humidity was 80.5 percent, or 6 percentage points below that of 1954. Interestingly, in 1953 7 of the 8 days of above-the-critical level readings were consecutive. This would have made for heavy and continuous reproduction of the downy mildew fungus, but there had not

been previous build-up of infection, and the disease did not develop.

In the 1951 and 1952 seasons, also years with low incidence of downy mildew, the morning relative humidity averages, 83.3 and 81.1 percent respectively, were low as compared with the bad year, 1954.

Specific observations during the 1954 growing season are of some significance. On April 18 and 19 the morning relative humidity readings were low, 85 and 86 percent respectively. Four days later the cantaloupe beds under observation, which had been brown in tone, had become green by virtue of active vegetative growth, and it appeared as if they might have recovered from the severity of early infections. However, 95 percent humidity occurred on two successive mornings, April 20 and 21, and four days after that practically all the new leaves showed fresh infections, and the bed again became brownish.

Other random observations concerning air humidity in relation to incidence of downy mildew in cantaloupe are also rather significant. On one large cantaloupe operation with 1200 acres planted to the crop, it was noticed that in areas protected from the wind early and severe downy mildew occurred. Several such spots were seen on the leeward side of tall trees growing along the banks of irrigation and drainage canals. In 1954, also, a large field had been strip-planted the fall before to blue panic grass to protect the young vines from hard February and March winds. In this field downy mildew became more severe than in more open fields. In one of the years when downy mildew in general was not a serious factor, a planting almost entirely surrounded by trees in a low-lying field near the Rio Grande River was badly attacked by downy mildew. Again, a field planted in the middles in a young citrus grove and thereby protected somewhat from air movement became heavily infected, whereas a nearby open field was almost entirely free. All these observations indicate that high humidity favored by local conditions contributed to severe damage from downy mildew.

DISCUSSION

From these observations on local conditions contributing to the occurrence of downy mildew, it would appear that judicious choice of planting sites would materially reduce the extent of damage from the disease. Avoiding the possibility of air pockets would be desirable in that it would make for more air movement through the plants, thereby hastening the drying of leaves after irrigation, light showers, or heavy dews. The planting of wind-break strips in a large field certainly has its place for the protection of young plants against the hard whipping winds of February and March. However, after the plants have become tied together over the beds, the need for the wind-break no longer exists, and the strips can then be clipped close to the ground, thus allowing better air movement. One large-scale grower in the Lower Rio Grande Valley is definitely planning to follow this procedure in next year's plantings.

Most of this paper deals with the relation between relative humidity and the incidence of downy mildew, the early morning readings on relative humidity having received special attention. Considerable thought has been given to the possibility of developing a practicable means of applying daily weather reports to better advantage in timing the applications of fungicides. Closer cooperation with the Weather Bureau and the Extension Service may achieve this end.

The ideal procedure would be to obtain a prediction in the evening as to what the early morning relative humidity is likely to be, what the dew situation will be, and how early the temperature will rise sufficiently to dry the plants. A thorough application of a fungicide, either in the evening or early the next morning, when conditions known to favor infection are expected, would have great value in reducing the extent and severity of infection as compared with what would most certainly result without the fungicide. It is well established that thorough and timely application of fungicides can control downy mildew. On the other hand, in a series of successive days of low morning humidity, the applications might very well be wasted effort and expense.

A radio broadcast based upon up-to-the-minute readings on a reliable hygrograph, along with predictions as to the conditions that are likely to follow and perhaps a correlated disease-condition forecast, would contribute to an informed procedure on the part of the grower rather than one based on hit-or-miss guesswork. Detailed joint studies on the part of the weather man and the plant pathologist would probably bring about substantial improvement in the reliability of this gradually evolving plant disease "warning service". But even with the present status of knowledge on the subject, with the clear-cut demonstration of the relation of relative humidity to downy mildew, such a warning service would have immediate value.

By way of appraisal of the situation, judging only by the conditions of the last four years, the season of 1954 was an unusual one for the Lower Rio Grande Valley insofar as cantaloupe

production is concerned. The menace of a serious downy mildew epiphytotic might occur only once in four years. However, to judge by the history prior to 1951, it might well occur more frequently. Confronted by the prospect of bad downy mildew a grower would benefit greatly from a downy mildew warning service, including advice on applications of fungicides. In a year with lower than average incidence of downy mildew in prospect, the number of fungicidal applications needed would be only two or three for the season instead of the eight or more in a bad year. In such a year the costs of production would be proportionately lower than average, and the prospect for making a good crop would also be enhanced.

This paper has dealt exclusively with downy mildew in cantaloupes, but its conclusions would apply equally well to cucumbers and even to watermelons when downy mildew is a factor in production of those crops. Furthermore, the identical weather conditions, particularly high humidity, favor the incidence of other foliage diseases on potatoes, tomatoes, celery, carrots, and some other crops. A general "Plant Disease Warning Service" might evolve that would be of untold value to growers in the Lower Rio Grande Valley of Texas and nearby localities.

TEXAS SUBSTATION NO. 15, WESLACO

AN UNREPORTED TYPE OF RESISTANCE TO CUCUMBER DOWNY MILDEW

W. C. Barnes and W. M. Epps

In 1952, Barnes and Epps reported that cucumber Plant Introduction No. 197087 was apparently immune to anthracnose (Colletotrichum lagenarium (Pass.) Ell. & Halst.)[1]. It was also reported that this cucumber had some resistance to downy mildew (Pseudoperonospora cubensis (Berk. & Curt.) Rostow.). The lesions caused by mildew on this cucumber have been puzzling since it was first grown in 1951. In 1953 this was attributed to a different physiological reaction to the disease. Careful study of 197087, and of progeny from crosses in which 197087 was used as a parent, substantiated this conclusion in the spring of 1954.

Downy mildew lesions on all common cucumber varieties begin as small yellow spots, slightly angular in outline because of restrictions by large veins that cause one or more straight line breaks in the otherwise circular development. The spots enlarge rapidly, with the centers gradually becoming brown as the tissues die.

Inoculation of 197087 leaves with a heavy spore suspension produced irregularly shaped, brown lesions that frequently had a slightly water soaked appearance. These spots rapidly changed to a darker brown color as the tissues dried out. Under natural infection in the field, lesions on 197087 remained as very small circular, brown spots. The tissues within the lesions were never yellow. They appeared to die quickly after infection occurred. Sporulation in all cases appeared to be extremely sparse.

Since the tissues of "brown lesion" plants died more rapidly than those of "yellow lesion" ones, it sometimes appeared that they were more susceptible if readings were made seven to ten days after inoculation. Thus lines heavily inoculated in the seedling stage and rated as having only a moderate degree of resistance because of the dead cotyledonary tissues have grown out and were rated as highly resistant throughout the remainder of the season.

The full value of this "brown lesion" type of resistance cannot be determined until lines now breeding true for this character can be increased and field plantings made. It is believed, however, that it will give a degree of field resistance never attained by any "yellow lesion" variety such as Palmetto.

CLEMSON COLLEGE TRUCK EXPERIMENT STATION, CHARLESTON, SOUTH CAROLINA

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[1] Barnes, W. C. and W. M. Epps. 1952. Two types of anthracnose resistance in cucumbers. Plant Dis. Reptr. 36: 479-480.

YELLOW BEAN MOSAIC IN IDAHO[1]

C. W. Hungerford and Irvin G. Hillyer[2]

Yellow bean mosaic caused by Bean Virus 2 is an important bean disease in Idaho and in other states of the Pacific Northwest. A brief report is herein given of results of investigations of this disease, part of which were conducted by the junior author as a research fellow at the University of Idaho. The occurrence of yellow bean mosaic is associated with its principal host, white sweet clover, Melilotus alba Desr. The virus overwinters in this host and is readily transmitted to beans. Sweet clover has been used extensively for some years as a green manure crop and has become a common roadside weed in most agricultural areas of Idaho. The disease is prevalent in sweet clover even in isolated areas far from cultivated fields. Since the virus is readily transmitted by several aphids, this wide distribution on sweet clover is to be expected. Although there have been reported (6) (9) a number of other wild and cultivated hosts for Bean Virus 2, sweet clover appears to be the principal host for the strain of the virus involved in these investigations. See Figure 1 A for typical symptoms on this host.

Numerous strains of Bean Virus[2] have been reported. These include: the X-disease by McWhorter and Boyle (5), the pod-distorting strain by Grogan and Walker (2), isolate Number 1 by Hagedorn and Walker (4), the necrotic lesion strain by Zaumeyer and Fisher (8), and the severe yellow mosaic strain by Thomas and Zaumeyer (7). A careful study of several collections of the virus on beans and sweet clover from locations in Idaho and from Prosser, Washington, indicates that all of them were the type virus originally described by Pierce (6).

Thomas and Zaumeyer (7) compared the symptoms of strains of yellow bean mosaic in various species of plants and indicated that the type strain causes faint mottle in Great Northern U. I. 123 beans, but that the pod-distorting, necrotic lesion, and severe yellow mosaic strains do not cause systemic infection on this variety. Isolate 1, a strain of yellow mosaic virus reported by Hagedorn and Walker (4) and the X strain of McWhorter and Boyle (5) infect red clover, while the type strain does not. As no infection was secured on red clover by the authors and as the virus used caused systemic infection in Great Northern U. I. 123, it apparently meets the tests for the type strain of yellow bean mosaic virus in these respects.

Zaumeyer and Fisher (8) state that of the three varieties Great Northern U. I. Numbers 16, 31, and 123, only the last-named variety is infected by the type strain of yellow bean mosaic virus, this infection showing a very faint mottle.

Figure 2 shows the effect of the virus used in these experiments upon growth of five Great Northern varieties, U.I. Numbers 16, 31, 59, 56, and 123. Number U. I. 56 is an early variety which has been used in North Dakota.

Afanasiev and Morris (1) reported some resistance to yellow bean mosaic in Montana Great Northern Number 1 and Montana Great Northern Number 43-15 beans when compared with U. I. Great Northern Number 123. Seed of the Montana selections were tested in the field where they were exposed to infection by interplanting with white sweet clover plants infected with yellow bean mosaic. These selections were compared with Great Northern U. I. 123 and Great Northern U. I. 59, and no difference in susceptibility could be noted in the four Great Northern types. All four Great Northern types were infected 100 percent, and the symptoms were equally severe in all cases. In the greenhouse it was possible to secure infection on all plants of all four Great Northern types by inoculation with the virus from infected sweet clover or bean plants. Here again the symptoms were equally severe on all four Great Northern selections.

In the course of these investigations great variation was noted in expression of symptoms of yellow bean mosaic on field and garden beans and on peas. These symptoms varied from slight mottling, through leaf curling and rugosity, to extreme stunting and death of plants. Figure 3 shows the extreme lethal effects of the virus on the Mulitinko variety of South American garden bean.

Artificial inoculations were made with the virus from infected sweet clover plants on a number of species of Leguminosae. Young plants of the species to be tested were dusted with fine carborundum powder and then inoculated with fresh expressed juice of infected sweet

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[1] Published with the approval of the Director as Research Paper Number 380 of the Idaho Agricultural Experiment Station.

[2] Plant Pathologist and Graduate Fellow respectively, Idaho Agricultural Experiment Station, Moscow.

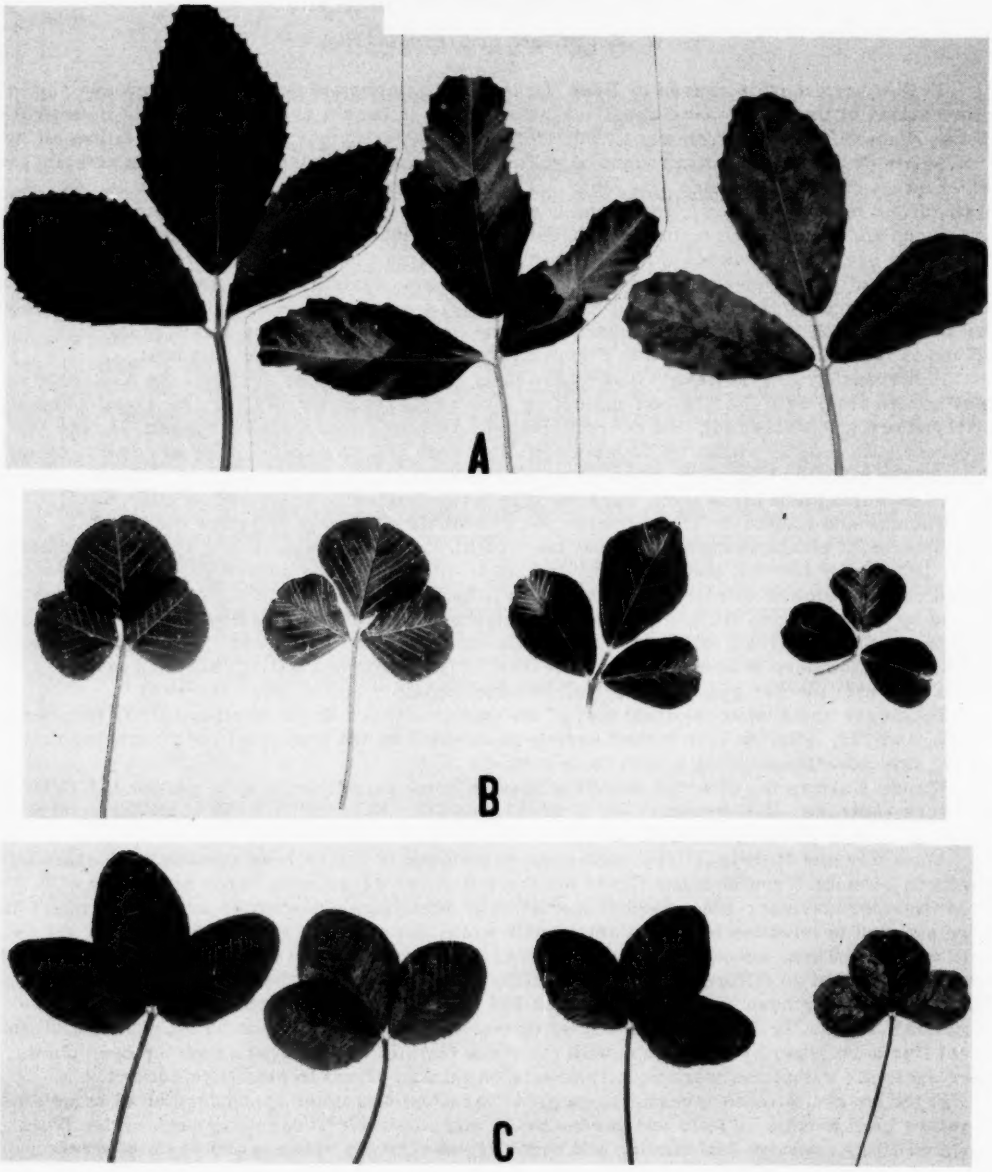


FIGURE 1. A -- Types of mottling noted on leaves of Melilotus alba Desr. when infected with yellow bean mosaic. Healthy leaf on left.

B -- Medicago lupulina L. infected with yellow bean mosaic virus. Note clearing of veins and chlorotic areas in the leaves. Healthy leaf on the left.

C -- Trifolium hybridum L. infected with yellow bean mosaic virus. Healthy leaf on the left.

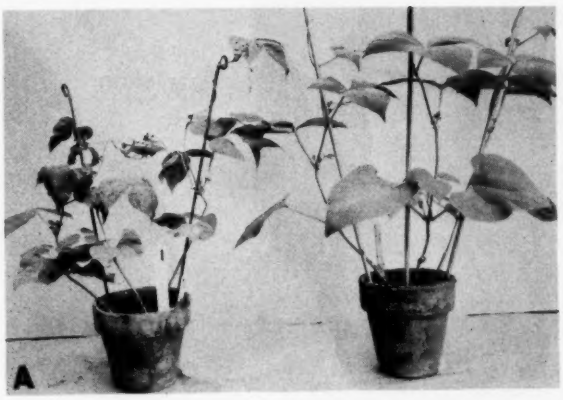
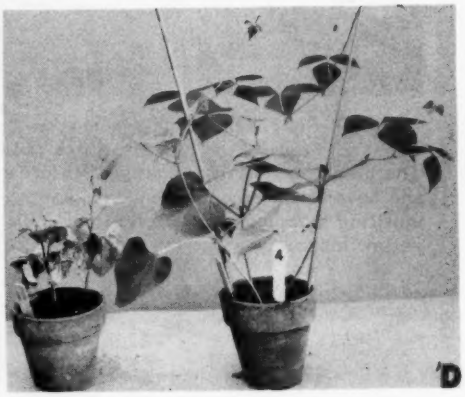
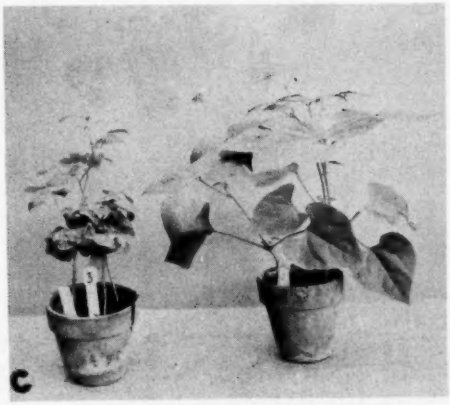


FIGURE 2. Reaction of several varieties of Great Northern beans to Bean Virus 2.
A -- Great Northern U. I. No. 16
B -- Great Northern U. I. No. 31
C -- Great Northern U. I. No. 59
D -- Great Northern U. I. No. 56
E -- Great Northern U. I. No. 123





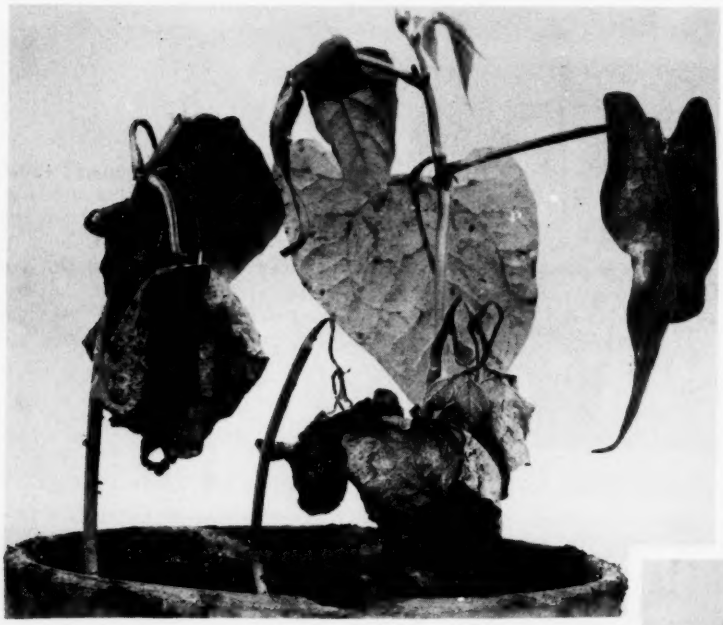


FIGURE 3. Extremely severe effect of Bean Virus 2 on Mulitinko bean. The plant on the right continued to grow and developed leaves with curling and mottling symptoms characteristic of yellow mosaic.

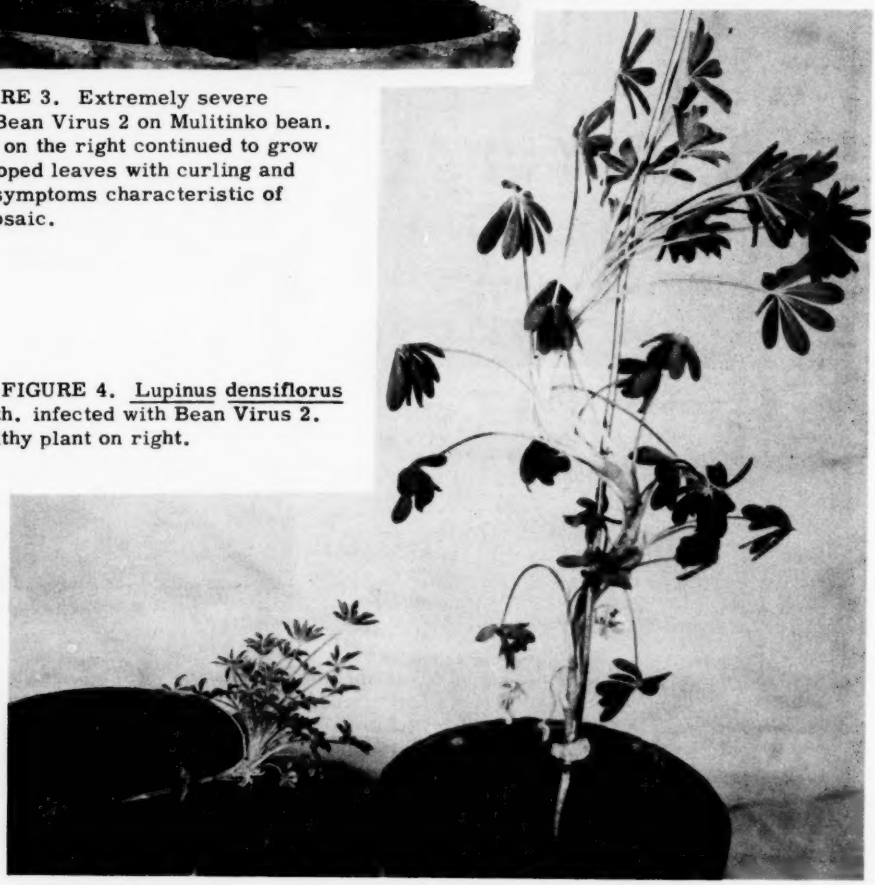


FIGURE 4. Lupinus densiflorus Benth. infected with Bean Virus 2. Healthy plant on right.

FIGURE 5. Crotalaria spectabilis Roth. infected with Bean Virus 2. Note killing of growing tip.

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FIGURE 3. Extremely severe effect of Bean Virus 2 on Mulitinko bean. The plant on the right continued to grow and developed leaves with curling and mottling symptoms characteristic of yellow mosaic.

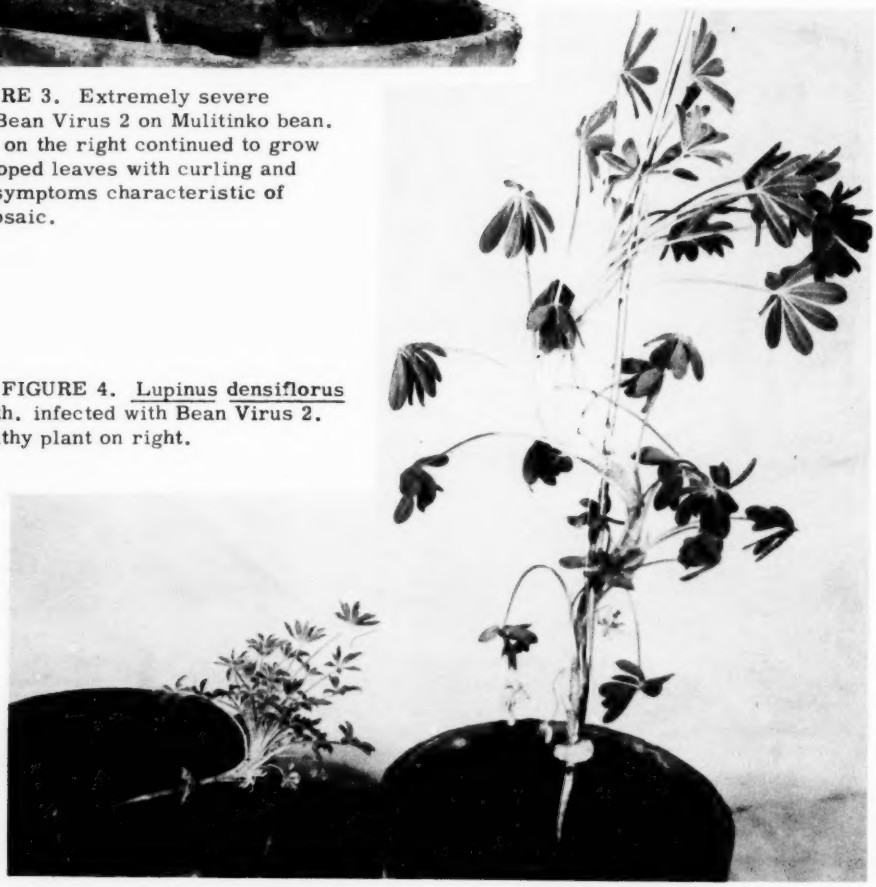

FIGURE 4. Lupinus densiflorus Benth. infected with Bean Virus 2. Healthy plant on right.

FIGURE 5. Crotalaria spectabilis Roth. infected with Bean Virus 2. Note killing of growing tip.

clover plants by rubbing the leaves. As a result of these inoculations, five new hosts for the type strain of Bean Virus 2 were discovered. These are: Vicia villosa Roth., Lupinus densiflorus Benth. (Fig. 4), Crotalaria spectabilis Roth. (Fig. 5), Medicago lupulina L. (Fig. 1 B), and Trifolium hybridum L. (Fig. 1 C).

Twenty-six horticultural varieties of peas were tested in the greenhouse for susceptibility to the type strain of Bean Virus 2. Table 1 summarizes the results of this test. All of the varieties, except Perfection and Gem, were susceptible. Infection varied from 14 percent to 100 percent. The Perfection variety has been previously reported as resistant to this virus (3) (6).

Table 1. Susceptibility of horticultural varieties of peas to Yellow Bean Mosaic (Bean Virus 2) when grown in the greenhouse at the University of Idaho, Moscow, Idaho. Artificial inoculations were made with inoculum obtained from Bean Virus 2- infected white sweet clover.

Varietal name	Plants inoculated versus plants infected	Percentage of plants infected
Laxton Progress	8/20*[a]	40.00
Profusion	16/16	100.00
Supurb	10/12	83.33
Cansweet	10/16	62.50
Wasatch	4/28*	14.28
Gradus	15/15	100.00
Pride	10/13	76.92
Union	5/10	50.00
Alaska	15/15	100.00
Surprise	15/16	93.75
Alah	8/12	66.66
Alderman	8/8	100.00
Dark Skinned Perfection	21/24*	87.50
Mardelah	15/16	93.75
Gems	0/23*	0.00
Perfection	0/23*	0.00
Thomas Laxton	11/12	91.66
Superior	0/25*[b]	
First and Best	16/28*	57.14
Idaho White	14/16	87.50
Little Marvel	0/27*[b]	
Pacemaker	7/13	53.84
Lennex	7/11	63.63
Walah	13/26*	50.00
Everbearing	8/24	33.33
Austrian Winter	11/16	68.75

[a] Numbers below line indicate number of plants inoculated; numbers above line indicate number of plants infected with Bean Virus 2.

[b] No symptom expression was found on these pea varieties, but when the inoculum from the inoculated peas was transferred to Mulitinko beans, definite yellow bean mosaic symptoms appeared.

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INSECT TRANSMISSION OF X-DISEASE VIRUS IN NEW YORK

R. M. Gilmer

In connection with the search for the vector or vectors of Sour Cherry Yellows and Necrotic Ring Spot Viruses of stone fruits, a limited number of attempts were made to discover an insect vector of X-disease Virus. Since the discovery of transmission of Western X-disease Virus (4, 1, 2) by leafhoppers of the genera Colladonus, Fieberiella, and Scaphytopius, special attention was paid to eastern representatives of these genera.

In August, 1952, approximately 35 adult Colladonus clitellarius (Say) collected in the field were caged on small chokecherry seedlings experimentally inoculated with X-disease Virus. These seedlings had been inoculated the previous February with a strain of X-disease Virus known to be contaminated with Necrotic Ring Spot Virus, and were showing anthocyanotic symptoms of X-disease.

FIGURE 1. Adult female Colladonus clitellarius (Say), a vector of X-disease virus in New York (approx. 4 1/2 x).

After a minimal 11-day acquisition feeding period, the 11 survivors were given access to a group of 25 small chokecherry seedlings. Nine leafhoppers survived the 20th day following transfer, but only three remained alive at the end of a 35-day period when the feeding test was concluded.

Three seedlings of the group of 25 exhibited initial symptoms of X-disease in September, 1953, approximately 12 months after the feeding period had concluded. The entire group was held through a second dormant period following its exposure to the leafhoppers, but only the three seedlings that had shown initial symptoms of X-disease in 1953 evidenced anthocyanosis in 1954. All three died in May, 1954, and none of them, nor any of the remaining 22 seedlings of the group, indexed positive for Necrotic Ring Spot Virus.

A second test, employing a lot of six adult C. clitellarius (five females and one male), was carried out in July, 1953. Inoculum was supplied from a different source of X-disease Virus known to be free of Necrotic Ring Spot Virus. X-disease Virus was transmitted to one chokecherry seedling of a group of ten. Symptoms appeared in June, 1954.

Similar tests were made in August, 1952, with five adult Scaphytopius sp. (S. acutus (Say) ?) and seven adult Fieberiella florii (Stal), but neither test resulted in transmission of the X-disease Virus, although both species have been shown to transmit Western X-disease Virus (1). These tests were too limited, however, to possess much significance.

In view of the fact that a close relative (C. geminatus (Van D.)) is a known vector of Western X-disease Virus (4, 2), and that C. clitellarius has been suspected of transmitting X-disease Virus in Illinois (3), the present evidence strongly indicates that C. clitellarius is a factor in the field transmission of X-disease Virus in New York. Whether this insect is primarily responsible for the rapid spread of X-disease in chokecherry in New York seems doubtful, however, in view of the sweeping and light-trap records made since 1950. Although not

extremely rare, the species is relatively uncommon. Collection of adults as early as June 3, in 1953, and as late as October 22, in 1951, suggests strongly that the insect may overwinter in New York as adults, but the species has never been collected in abundance.

Sweeping records indicate that C. clitellarius shows some preference for Prunus spp. as feeding plants for the adults, but collections have also been obtained from willow, box-elder, alfalfa, oak, birch, elderberry, and Viburnum sp. Of the various Prunus spp., chokecherry and plum appear preferred, although collections have been made from numerous other species, including sour cherry. The nymphal host plant is unknown to me.

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NEW STRAWBERRY DISEASE IN ARKANSAS

Harlan E. Smith[1]

SUMMARY

Record is made of a severe outbreak of a disease of strawberry plants resembling the aster yellows virus disease. The disease was almost universally present in strawberry plantings in Arkansas in May of 1954, affecting 20 percent of the plants in some fields.

A severe outbreak of a strawberry disease relatively new to Arkansas was encountered this season. The disease resembles the effects of Aster Yellows Virus in strawberries, as described by Frazier and Thomas (2), and chlorotic phyllody, described by Plakidas (1). First specimens of the disease in 1954 were encountered the first week in May in White County. Subsequent surveys revealed that the disease apparently appeared at this same time in all commercial strawberry producing areas in Arkansas. There is no other record of this disease in Arkansas except for a few specimens encountered in two plantings in White County in 1953.

FIGURE 1. Blakemore strawberry plants displaying symptoms incited by the unknown virus on the left. Normal plant on the right.

During May numerous strawberry plantings throughout northern and central Arkansas were observed. In only a few cases were fields seen where no plants with this disease were evident. The amount of the disease in each field varied from a few scattered plants to as many as 20 percent of the plants affected. Diseased plants were scattered at random about the fields. It has not been possible to correlate the severity of the disease with the location of plantings, source of planting stock, or cultural practices. The age of the planting, however, appears to have some bearing upon the amount of plants showing disease symptoms. Young vigorous plantings one or two years old generally had most diseased plants, while in older plantings only a few diseased plants were usually evident. Diseased plants have been observed in fields set this spring.

Three sets of disease symptoms have been noted. Although each may be a separate disease, until more information is obtained they are being considered different manifestations of the same disease.

One set of symptoms resembles closely those described by Frazier and Thomas (2) and by

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Plakidas (1). These plants are small, have a clumped appearance, and phyllody of the flowers. Plants with these symptoms were noted only rarely.

The most commonly encountered diseased plant is one with the outer leaves lying flat to the ground with the leaflets curled upward (Fig. 1). Petioles and stolons tend to be red in color rather than green. New leaves are dwarfed, leaflets are cupped and have chlorotic edges. Fruit does not develop normally but remains as green "buttons" until becoming dried and shrivelled. These symptoms resemble those described for the Strawberry Yellows Virus in susceptible varieties. Since the variety Blakemore, which is used in practically all commercial plantings in Arkansas, does not show any leaf symptoms when affected by the yellows virus, there is no possibility of this disease being confused with it.

The third set of symptoms, which has been noted in relatively few fields, involves a sudden wilting and death of the diseased plant. The sudden wilting is not associated with any evident injury to the roots or crowns.

Since this disease was not noted prior to 1953 in Arkansas, its development in 1954 represents an alarming increase. Although symptoms resembling this disease have been noted in other areas of the country the author is not aware of any record of such a severe outbreak as is noted here.

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PYTHIUM APHANIDERMATUM, THE CAUSAL AGENT OF DAMPING-OFF IN SOME CITRUS SEED BEDS

T. A. DeWolfe, E. C. Calavan, and J. R. Sufficool

On July 28, 1953, we received a report from Thermal, California that Rough Lemon seedlings that had been planted in a shaded seed bed and watered by basin irrigation were damping-off. We collected some of the affected seedlings and noted that the soil temperature at the time of collection was approximately 34° C.

Microscopic examination of these seedlings revealed oospores in necrotic tissues near the advancing lesion margins. Water-agar cultures were made and Pythium aphanidermatum (Edson) Fitzpatrick[1] was recovered. Fawcett[2], Harvey[3], and Wager[4] mention that Pythium spp. are among the fungi associated with damping-off of citrus seedlings, but a search of the literature has yielded no specific reference to Pythium aphanidermatum as a causal agent of damping-off in citrus.

On August 11, 1953, chloropicrin-fumigated soil was placed in 12 8-inch pots. On the surface of each of six of these pots were distributed 40 sweet orange seeds and on the surface of each of the remaining six were distributed 40 Rough Lemon seeds. These 12 pots were then separated into three groups of two sweet orange and two Rough Lemon pots each, and treated as follows: To each pot of the first group was added 3/4 inch of autoclaved sand. To each of the second group 40 hemp seeds, sterilized in water, were added and covered with 3/4 inch of autoclaved sand. To each of the third group were added 40 hemp seeds from a water culture of hemp seed which had been inoculated three days previously with Pythium aphanidermatum originally isolated from damped-off Rough Lemon seedlings. These seeds were then also covered with 3/4 inch of autoclaved sand.

Each of the 12 pots was then placed in a 5-gallon can and flooded for two hours with tap water. After flooding, the pots were allowed to drain and were placed in a cabinet in which the air temperature was 34.5° C and the soil temperature 26°. The following day each of the 12 pots was reflooded for two hours, drained and returned to the cabinet. After an interval of six days, the pots were again flooded and drained two days in succession. This was repeated on August 24 and 25 and on September 2 and 3. Except during periods of flooding, the soil temperature was maintained between 31° and 35°. The air temperature in the cabinet was held between 37° and 45°.

Table 1. Emergence and survival of sweet orange and Rough Lemon seeds and seedlings inoculated with Pythium aphanidermatum.

Treatment	Seeds planted	Seeds from which seedlings emerged and survived	
	No.	No.	Percent
Sweet orange inoculated at planting	80	8	10
Sweet orange inoculated at emergence	80	11	1
Sweet orange controls	80	46	58
Rough Lemon inoculated at planting	80	3	4
Rough Lemon inoculated at emergence	80	3	4
Rough Lemon controls	80	42	53

[1] Dr. John T. Middleton kindly verified the authors' tentative identification.

[2] Fawcett, H. S. 1936. Citrus Diseases and Their Control. McGraw-Hill Book Company, New York.

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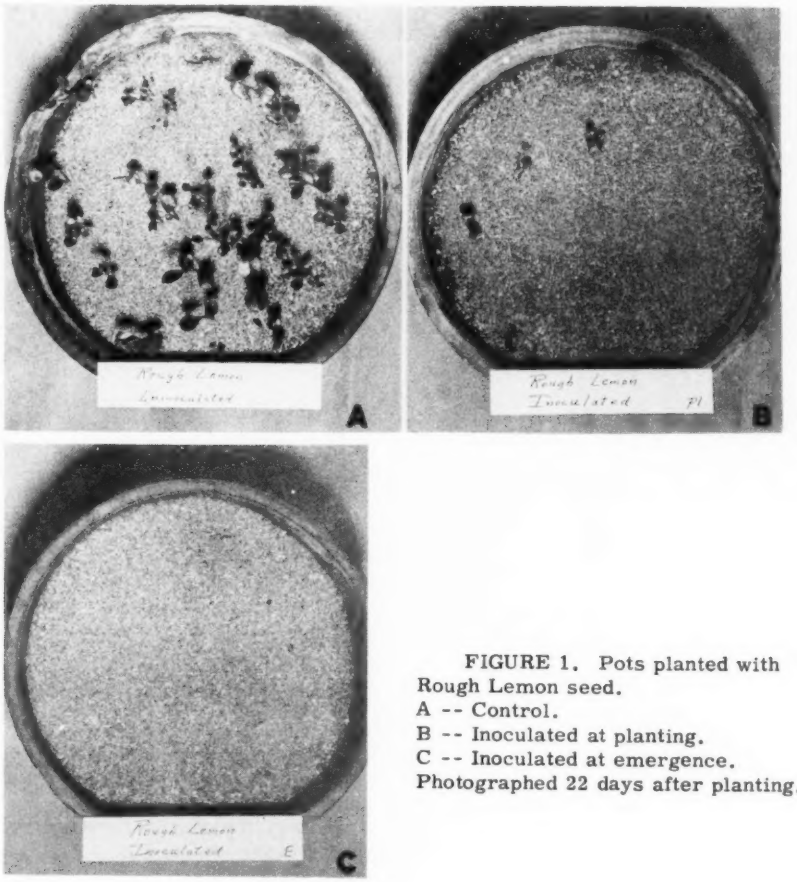

FIGURE 1. Pots planted with Rough Lemon seed.
A -- Control.
B -- Inoculated at planting.
C -- Inoculated at emergence.
Photographed 22 days after planting.

On August 23, soon after the first seedling emergence, the four pots which had not previously received hemp seed were inoculated by pressing sterilized hemp seeds, upon which Pythium aphanidermatum had grown three days, into the sand cover at the rate of one hemp seed to each citrus seed. This inoculation was made in order to permit infection at about the time of emergence.

Infection was noted on Rough Lemon seedlings, inoculated at emergence, only 27 hours after inoculation. Fifty-three hours after inoculation eight of the 11 Rough Lemon seedlings which emerged had damped-off. Oospores were found in one of these when it was examined a few hours later. Pythium aphanidermatum was easily recovered from several seedlings. Few seedlings in the inoculated pots emerged and survived (Fig. 1). Emergence and survival are shown in Table 1.

It is concluded that Pythium aphanidermatum is capable of inducing damping-off of sweet orange and Rough Lemon seedlings under conditions of temperature and soil moisture similar to those prevailing during the summer in citrus seed beds in the Coachella Valley. The development of extremely high percentages of pre-emergence rot following inoculation experiments suggests that this fungus is important also in pre-emergence rot in citrus seed beds under high temperature conditions.

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THREAD-BLIGHT (PELLICULARIA KOLEROGA) IN LOUISIANA

E. C. Tims, P. J. Mills, and Beatrice Exner[1]

Introduction

Thread-blight of fig was reported in Louisiana in 1927 by Tims (1), who mentioned that "the disease prevailed to the usual extent." This is apparently the first published account of the disease in the State. Later the disease was reported in Louisiana by Tims (12), Tims and Mills (13), Tims and Bonner (16), and Large (5) on a number of other hosts. Included in the present paper are some of the studies and observations regarding 1) the nomenclature of the thread-blight organism, 2) some of its host plants in Louisiana, and 3) the control of the disease on the most important economic plants on which it occurs in the State.

History of the Disease and Some Host Plants

The "koleroga" disease of coffee attributed to Corticium koleroga (Cke.) Hoehn. has been known for years in the West Indies, Central and South America, Asia, Africa, Australia, and a number of islands scattered over the world where favorable conditions of temperature and moisture obtain. A similar disease of pome fruits was reported by Stevens (10) in the southern United States in 1907, and later described by Stevens and Hall (11). They gave the name "Hypochnose" to the disease because the causal organism resembled Hypochnus ochroleucus Noack. In 1927 Weber (19) reported a thread-blight of several plants in Florida caused by Corticium stevensii Burt. The same year Wolf and Bach (20) described a similar disease of citrus and pomaceous plants caused by Corticium koleroga (Cke.) Hoehn. The latter two workers considered the thread-blight fungus observed in the southern United States to be identical with that causing the koleroga disease of coffee in the tropics.

Nomenclature of the Fungus

The thread-blight organism was first described on coffee from India by Cooke (2) in 1876. He regarded it as a Hyphomycete and called the fungus Pellicularia koleroga. In 1910 Von Hoehnel redescribed the fungus from Cooke's type material and gave it the name Corticium koleroga. Noack (7) named a thread-blight fungus on pomaceous plants in Brazil Hypochnopsis ochroleuca, which was changed by Saccardo to Hypochnus ochroleucus Noack. This binomial was used in references to the thread-blight fungus by other workers, including Nowell (8), Stevens and Hall (11), and Burt (3). Stevens and Hall described a disease of pomaceous plants which they designated as "hypochnose." Burt (3) in 1918 studied the thread-blight fungus on coffee and designated it as Corticium koleroga (Cke.) Hoehn. Later Burt (4) compared the fungus from pomaceous plants in the United States with the one from coffee and assigned it the new name Corticium stevensii Burt. According to Burt Corticium stevensii differed from C. koleroga principally in the production of sclerotia.

In 1927 Weber (19) described a thread-blight of fig and several other plants. He attributed the disease to the fungus Corticium stevensii Burt. The same year Wolf and Bach (20) reported a thread-blight of citrus and pomaceous plants caused by Corticium koleroga (Cke.) Hoehn. The latter workers considered C. koleroga and C. stevensii to be identical. In the earlier reports from Louisiana the thread-blight fungus on fig was called C. koleroga. During the period from 1924 to 1943 each of the two species names was used about equally by the different workers in the Southern States.

In 1943 Rogers (9) published a revision of the genus Corticium in which he included many of the forms in the genus Pellicularia. He went back to Cooke's original description of the thread-blight or koleroga fungus on coffee and called it Pellicularia koleroga Cooke. Rogers also included Corticium stevensii and Corticium koleroga under the name P. koleroga. Following Roger's paper on Pellicularia the name of the thread-blight fungus was gradually changed in the literature from C. stevensii and C. koleroga to Pellicularia koleroga.

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In the past few years Pellicularia koleroga Cke. has become the generally accepted name for the thread-blight fungus that occurs on many plants in the more southern of the United States.

FIGURE 1. Typical fig branch affected by the thread-blight fungus. Note the presence of sclerotia, hyphal threads, and basidial mat on leaf.

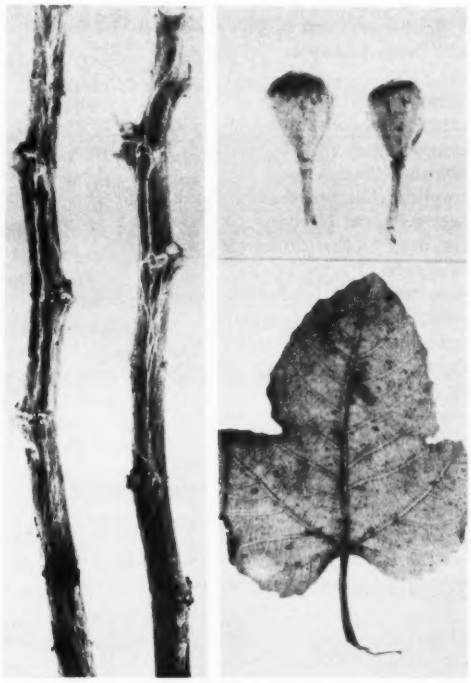

FIGURE 2. Hyphal threads on fig twig, basidial mats on leaf and fruit.

Economic Importance

Thread-blight is the most important disease of figs in Louisiana. Many trees in the southern part of the State are partially defoliated by the fungus during periods of warm weather and high humidity in the summer months. The twigs, leaves, petioles, and fruit are subject to attack (Fig. 1, 2). If defoliation takes place before the fruit matures the figs will not ripen. There is often little permanent damage to the affected trees. The writers have observed a number of fig trees that have been affected with thread-blight over periods from four to ten years with no pronounced effect on their growth.

Thread-blight has caused some defoliation of tung trees as well as minor injury to a number of different plants in Louisiana (16). Large (5) reported that thread-blight was one of the most serious diseases of tung trees in the State. The writers have observed the disease causing severe defoliation of scattered apple, pear, and plum trees in local areas where conditions were especially favorable for its development. The disease has also caused unsightly defoliation of Pittosporum, crepe myrtle, rose bushes, and other ornamentals in numerous gardens in the southern part of the State. Thread-blight is of minor importance on most of the known host plants in Louisiana with the exception of fig and tung trees.

Some Host Plants in Louisiana

Thread-blight has been observed by the writers on a number of plants in Louisiana. In all cases typical shiny silk-like threads were observed on infected leaves and branches. On most of the plants the small, brown sclerotia were found on the twigs, and basidial mats had developed on the lower surface of the leaves. The list of known host plants for the thread-blight fungus in the State is as follows:

Apple (Pyrus malus)
Azalea (Rhododendron spp.) Indian hybrids
Banana shrub (Michelia fuscuta)
Boxwood (Buxus sp.)
Camphor (Cinnamomum camphora)
Cherry laurel (Prunus caroliniana)
Chinaberry (Melia azedarach)
Crabapple (Pyrus sp.)
Crepe myrtle (Lagerstroemia indica)
Dewberry (Rubus trivialis)
Dogwood (Cornus drummondii)
Elderberry (Sambucus canadensis)
Elm (Ulmus spp.)
Euomymus (Euonymus sp.)
Fig (Ficus carica)
Flowering almond (Prunus sp.)
Flowering quince (Chaenomeles lagenaria)
Golden rod (Solidago altissima)
Honeysuckle (Lonicera japonica)
Morning glory (Ipomoea sp.)
Pear (Pyrus communis)
Pecan (Carya illinoensis)
Pepper vine (Ampelopsis arborea)
Persimmon (Diospyros virginiana)
Pittosporum (Pittosporum tobira)
Plum (Prunus angustifolia)
Pomegranate (Punica granatum)
Quince (Cydonia oblonga)
Rambler rose (Rosa sp.)
Rose (Rosa sp.)
Satsuma (Citrus reticulata)
Silver maple (Acer saccharinum)
Tievine (Jacquemontia tamnifolia)
Tung (Aleurites fordii)

In 1943, Large (5) reported the following host plants for thread-blight in the State: dogwood (Cornus florida), wild crabapple (Malus angustifolia), blackberry (Rubus sp.), columbine (Aquilegia canadensis), American holly (Ilex opaca), and gall berry or ink berry (Ilex glabra).

Control

Control of thread-blight on fig in Louisiana has received some attention in the past 15 years. Tims (15) and Tims and Mills (17) reported good control of the disease by one application of copper sulfate-lime-arsenite spray mixture during the dormant season. Other tests by Tims and Bonner (16) showed that one or two applications of Bordeaux mixture greatly reduced the amount of thread-blight. Recent (18) tests have shown that one or two applications of tribasic copper sulfate (4-100) in late May or early June usually gave satisfactory control of the disease until after the fruit ripened in July.

Large and his co-workers (5) (6) published accounts of thread-blight control in tung orchards in Louisiana and other States. They found that control by pruning was feasible if the disease was limited to a few branches or trees. Severely infected tung orchards adjacent to swamps containing diseased native plants required at least one spray per season, of 6-6-100 or 6-2-100 Bordeaux mixture, applied between late May and early June. These workers also found that pruning out remaining infected branches that appeared about 30 days after the spraying might be necessary where infection was severe.

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THE OCCURRENCE OF CLITOCYBE ROOT ROT ON TUNG TREES IN INDIA DOUBTFUL

Arthur S. Rhoads

In the list of diseases affecting tung (Aleurites spp.) prepared by Wiehe (11), root rot of A. fordii, caused by Clitocybe tabescens (Fr.) Bres., is recorded as occurring in the United States and India. The Indian record is based on a paper by Prashad (4), or perhaps on the abstract in the Review of Applied Mycology (5). Prashad's original paper, as he says himself, is a compilation from all sources. It discusses the cultivation of A. fordii in India, and considers various adverse factors including diseases, in other countries as well as India. The very brief section on fungi contains a general paragraph reporting C. tabescens as a cause of root rot of tung trees, with nothing to indicate where this disease occurred and no references. However, the mention of gumming clearly shows that the brief paragraph was based on an article by the writer (6), reporting C. tabescens as a cause of root rot in tung plantings in Florida. As often happens with general articles, the lack of a definite statement concerning locality led to the erroneous conclusion that the disease occurred in India.

So far as is known at present, C. tabescens has a discontinuous distribution limited to the eastern part of the United States, Europe, and China. Dennis (1) stated that C. tabescens and Armillaria mellea do not appear to be present in Trinidad. [1]

In the United States, C. tabescens is known to range from points as far north as New York and Michigan southward to Florida and the Gulf States and west to Illinois, Kansas, Missouri, Oklahoma and eastern Texas. Zeller (12) reported this fungus on rotted wood in the soil at Corvallis, Oregon, but later he decided, in correspondence with the writer, that the identification was incorrect. The fungus appears to occur with greatest frequency in the southern States but root rot caused by it has been reported to occur only in the southeastern States (7).

In Europe, C. tabescens was known to occur long before it was recognized under various names in the United States, having been described first by Scopoli in 1772. It has been reported from England, France, Portugal and Spain, and eastward through Germany, Austria, Czechoslovakia, Hungary, northeastern Italy, Romania, and northern Yugoslavia in central Europe, as these countries are now limited, and apparently occurs with greatest frequency in the southern part of Europe. Strange to say, however, the fungus has never been reported as pathogenic in Europe and always is recorded as a saprophyte, usually on stumps and roots of oak and chestnut.

C. tabescens has also been recorded by Teng (8, p. 68; 9, p. 474) and by Teng and Ou (10) from Chekiang and Kiangsu Provinces in eastern China, where its occurrence is given as on a stump.

A root and corm rot of bananas, attributed to Clitocybe sp. and Armillaria mellea, has been reported by Magee (2) and others since 1934 as sometimes causing losses in plantations established on virgin forest land in New South Wales, Australia. Unfortunately, no further information concerning the Clitocybe sp. in question has been given even in the most recent account of this disease. Peace (3) reported Clitocybe sp. causing a butt rot of eight European larch trees (Larix decidua) in Great Britain. It would be of considerable interest to know something more definite in regard to the species of Clitocybe involved in these instances of disease. C. tabescens is the only species of this genus known to the writer to be pathogenic.

[1] Since the preparation of this note, the writer's attention has been called to a report of severe occurrence of Clitocybe tabescens on Coffea canephora in plantations on the east coast of Madagascar (Bouriquet, G., and H. Barat. Parasitisme de Clitocybe tabescens (Fr. ex Scop.) Bres. sur Coffea canephora Pierre. In Rapports et Communications, Huitième Congrès International de Botanique, Sections 18, 19 et 20. Paris, 1954. p. 79). These authors believe that the Madagascar fungus is a distinct variety.

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OBSERVATIONS ON THE OCCURRENCE OF THE STEM CANKER AND POD AND STEM BLIGHT FUNGI ON MATURE STEMS OF SOYBEAN[1]

A. A. Hildebrand[2]

SUMMARY

Mature stems of soybeans collected in the autumn of 1953 and subsequently left to stand for from three to four weeks in shallow water in a humid atmosphere were examined critically for occurrence of Phomopsis and Diaporthe spp. Pycnidia of the Phomopsis type, which varied widely in their morphology, occurred on a large proportion of the 1046 stems examined. Despite various manipulation of pycnidium-bearing stems and the pairing of 20 monoconidium isolates no evidence of a sexual reaction was observed. Perithecia occurred on 123 (11.7 percent) of the stems and three stems were unique in having produced pycnidia similar in appearance to perithecia of Diaporthe. Monoascospore cultures obtained from five stems, two of which showed only a single perithecium each, and three of which had long-beaked perithecia intermixed with pycnidia, gave rise to Phomopsis isolates which are regarded as being representatives of the imperfect stage of the pod and stem blight organism, D. phaseolorum var. sojae, shown by Welch and Gilman (5) to be heterothallic. Monoascospore cultures derived from 20 stems which showed either the cespitose or a seemingly more dispersed type of perithecial development gave rise to isolates of the stem canker organism, D. phaseolorum var. batatatis, which as Welch and Gilman (5) have shown, is homothallic and produces its perithecia in cespitose groups. In addition to the ascus stage, certain of the isolates revealed the presence of conidia similar to the alpha spores of Phomopsis. These conidia were produced sparsely, presumably on the mycelium. Other isolates produced, in addition to the ascus stage, rare ectostromatic bodies containing locules from which typical Phomopsis spores of the alpha type were exuded. Such evidence of an imperfect stage of D. phaseolorum var. batatatis as a pathogen of the soybean has not been reported heretofore.

INTRODUCTION

Studies of the stem canker and pod and stem blight complex of soybeans have been in progress at Harrow, Ontario, for a period of several years. Isolates of Phomopsis have been readily and consistently obtained from stems which showed symptoms now regarded as typical of pod and stem blight, that is, linear rows of fruiting bodies (pycnidia) or fruiting-body initials. Similarly, isolates of the homothallic fungus which produces its perithecia in cespitose groups and which was regarded by Welch and Gilman (5) to be Diaporthe phaseolorum var. batatatis, have been readily obtained from stems showing the girdling type of lesion typical of stem canker. Meanwhile, however, Diaporthe phaseolorum (Cke. & Ell.) Sacc. var. sojae (Lehman) Wehm., shown by Welch and Gilman in 1948 (5) to be heterothallic and to produce its perithecia singly on an effuse stroma, had not been encountered. For a long time the writer had felt that as D. phaseolorum var. sojae had been found elsewhere in areas that are almost ecologically identical with southwestern Ontario, the fungus must surely be present on the same host in the latter area. Consequently, it was decided last autumn to make a renewed, concerted effort to find the fungus. The attempt has been successful. D. phaseolorum var. sojae has been found; and of even greater interest was the additional discovery of an imperfect stage of D. phaseolorum var. batatatis, such a stage having not been reported heretofore for this fungus. Details of the studies are recorded below.

MATERIALS AND METHODS

On October 8, November 2, and November 16, 1953, 1440 mature stems of the varieties Lincoln, Blackhawk, and A. K. Harrow, were collected in the laboratory experimental plots (80 stems per date per variety per location). Half of the stems were obtained from a site where soybeans had been grown for four years in succession (old plots), the other half from a location where, as far as could be ascertained, they had never been grown previously (new plots). The

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stems were stored in a chamber cooled to 40° F. From there they were transferred as required to the greenhouse where, in adoption of a technique suggested by Luttrell (3), they were left to stand in 1/4 to 1/2 inch of water. After a three- to four-week period during which the water was changed daily, successive lots of stems were examined microscopically. From the outset it was found that consistently critical examination was necessary in order to avoid making wrong determinations. For example, what often appeared even under the dissecting microscope to be pycnidia were found when sectioned and examined under the compound microscope to be nonspore-producing stromatal bodies[3]. Moreover, in certain instances, only resort to the compound microscope revealed that fruiting bodies which closely resembled perithecia were in reality pycnidia (Fig. 2). Altogether, 1046 stems were examined in careful detail.

OBSERVATIONS ON THE INCIDENCE AND KIND OF FRUITING BODIES OF STEMS

A. Occurrence of Pycnidia

The first stems to be examined were those of the October 8 series obtained from the new plots. As Figure 1 shows, there is no indication of pycnidia on these stems. The reason for this is twofold. In the first place, there were too few pycnidia to attract attention, and in the second the intent at the outset was to confine attention to perithecia alone. By so doing it was hoped to repeat the success of Welch and Gilman (5) in finding D. phaseolorum var. sojae and D. phaseolorum var. batatatis and in being able to distinguish the one from the other on the basis of the difference in their types of perithecial development. When the examination of the

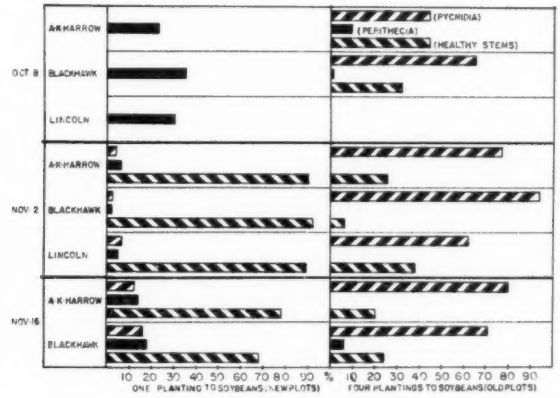


FIGURE 1. Relative occurrence of pycnidia and perithecia on mature stems of soybeans collected from plots planted one year (left) and four years (right) to soybeans.

stems collected on October 8 from the old plots was begun, the first and most striking observation was the much greater abundance of pycnidia on them than in the earlier-examined, corresponding series from the new plots. It became immediately apparent that though primary interest might center on perithecia, cognizance would also have to be taken of pycnidia. As Figure 1 shows clearly, the tendency for the much greater abundance of pycnidia on stems from

[1] When transferred to nutrient media these bodies, to which the term "stromatal islands" might be applied, have yielded cultures of Phomopsis and of D. phaseolorum var. batatatis. They may well be regarded, therefore, as the precursors of either pycnidia or perithecia.

the old plots than on those from the new, holds true throughout the series, the contrast being especially striking for the series of November 2.

The pycnidia varied widely in their morphology. Many, erumpent singly from the stem tissues and only slightly, if at all, papillate, tended to be disposed linearly, and in the aggregate presented the pod-and-stem-blight type of symptom (Fig. 3). Others, in marked contrast, originated on or within carbonaceous, more or less pulvinate, stromatal bodies aggregated crust-like on the surface of the stems (Fig. 6). Pycnidia originating from such a substratum developed long beaks which, whether branched or unbranched, often showed a most distorted type of growth (Fig. 4). Pycnidia of the latter type tended to occur most consistently towards the end of the stem that had been in the water. Thus, it appeared that the morphology of pycnidia might be modified by the availability of moisture. Although this may be true to a point, cultural studies have shown that pycnidia of isolates differ widely in their morphology under conditions in which moisture is neither a variable nor a limiting factor. What these morphological differences may signify taxonomically is not yet clear.

Pycnidia occurring naturally on the stems as well as those of isolates from the stems grown on various agar media and on steamed soybean stems produced typical Phomopsis spores of the alpha and beta types. In most of the pycnidia spores of the alpha type predominated. Frequently, spores especially of this type were observed to have been exuded from the pycnidia either in globules (Fig. 5) or in conspicuous "tendrils" (Fig. 6). In a few pycnidia beta-type spores (stylospores) were in the majority. No clear-cut evidence was adduced as to what particular substratum or environmental condition might be especially conducive to the production of the one or the other type of spore. All attempts to induce the stylospores to germinate were ineffectual. The alpha spores, on the other hand, germinated readily, especially when, in a water suspension, they were streaked on the surface of standard potato dextrose agar in Petri plates. By transplanting single germinating spores from such plates, monoconidium cultures were easily obtained.

To date, no manifestation of sexuality on the part of the Phomopsis sp. or spp. has been observed. Stems showing an abundance of pycnidia have been subjected to such manipulations as alternate freezing and thawing, wetting and drying; but no stage other than the pycnidial has been observed. Also, 20 different isolates of monoconidium origin have been paired in all possible combinations on steamed soybean stems but no sign of a perfect stage has been seen.

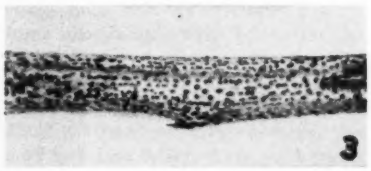
Nothing is yet known of the pathogenic capabilities of the more recently obtained Phomopsis isolates. Incidentally, however, in the late summer of 1952, the pathogenicity of a number of earlier-obtained and apparently closely similar isolates was tested under field conditions. Certain of them were found to be virtually nonpathogenic whereas others were capable not only of infecting stems and producing typical symptoms of pod and stem blight but also of reducing yields appreciably.

B. Occurrence of Perithecia

By referring again to Figure 1, it may be noted in general that perithecia occurred in greater abundance on stems from the new plots than on those from the old. This would seem to be the opposite of what might be expected, especially as the soil on the site of the new plots was virgin for soybeans. Since seed from the same lots was used for planting both series of plots, the difference in the occurrence of perithecia on stems of plants from the two sites cannot be attributed to differences in seed-borne inoculum. The circumstances confirm evidence adduced in other phases of the investigation that Diaporthe spp. capable of infecting soybeans are indigenous to many of the agricultural soils of southwestern Ontario.

Of the 1046 stems examined, 126 (12 percent) showed perithecial or perithecium-like development. Upon more critical re-examination these 126 stems were sorted into categories as follows: (a) 100 which showed an abundance of perithecia mostly of the cespitose type and which bore pycnidia often contiguous to but never intermixed with the perithecia; (b) 18 which showed perithecia of a more dispersed type; (c) three which showed beaks that were indistinguishable from those of perithecia (Fig. 2) but found to be those of pycnidia (An isolate of this organism grown on steamed soybean stems produced its long-beaked pycnidia in cespitose groups (Fig. 7) that resemble similar grouping of the perithecia of D. phaseolorum var. batatatis); (d) two which showed a single perithecium and no evidence of any other fruiting bodies; (e) three which showed especially long-beaked perithecia intermixed with pycnidia.

From exudations at the tip of perithecial beaks on stems in categories (a), (b), (d), and (e), ascospores were transferred to drops of sterile water, plates were streaked from the suspension, and germinating ascospores (at least ten from each suspension) were transferred to



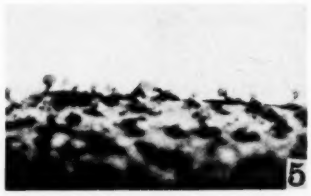


FIGURE 2. Pycnidia on soybean stem with beaks like those of perithecia of Diaporthe.

FIGURE 3. Pycnidia arranged linearly on soybean stem presenting typical pod and stem blight symptoms.

FIGURE 4. Pycnidial beaks showing distorted type of growth.

FIGURES 5 and 6. Globular (Fig. 5) and tendril-like (Fig. 6) types of spore exudation from pycnidia. In Fig. 6 note carbonaceous, stromatal bodies aggregated crust-like on surface of stem.

FIGURE 7. Cespitose type of pycnidial development on steamed soybean stem.

FIGURE 8. Cespitose type of perithecial development characteristic of Ontario homothallic Diaporthe.

tubed slants of potato dextrose agar[4]. Subcultures were grown on steamed soybean stems. After three weeks' growth, cultures were examined for the first time and then at two-week intervals. Data relevant to time of appearance and kind of fruiting bodies, size of spores, etc., were entered on a large wall chart, an examination of the accumulated recordings on which permitted at any time a rapid and accurate comparison of isolates or groups of isolates. Briefly summarized, results as related to the categories established above are as follows:

Categories (a) and (b): Monoascospore cultures derived from perithecia on stems in these two categories (four from (a) and 16 from (b)) showed three different phenomena which led to their being differentiated into groups as follows:

Group 1 -- Monoascospore reproducing the ascus stage but no evidence of an imperfect stage.

[4] Earlier in the investigations Difco p. d. a. was used. It was found, however, that fruiting-body formation took place more quickly and profusely on "natural" p. d. a. (1% dextrose), and the adoption of the latter effected appreciable saving of time.

Group 2 -- Monoascospore reproducing the ascus stage plus conidia of the Phomopsis type (alpha spores) borne sparsely, presumably on the mycelium and remote from the perithecia. What were regarded as mature conidia were single-celled, hyaline, and contained two conspicuous droplets (guttulae), one at each end. In shape they were elliptical and rounded at both ends and averaged about 6.0 x 2.8 μ in size. Conidia in immature stages were always present. They varied greatly in size and were nonguttulate. Some were budding, yeast-like, and others had conidiophores still attached.

Group 3 -- Monoascospore reproducing the ascus stage plus rare ectostromatic bodies containing locules from which conidia of the Phomopsis type (mostly alpha spores) were extruded in creamy masses; also, rarely, pseudo-pycnidial bodies containing only stylospores. The conidia were more variable in shape than the mature ones of Group 2. In addition to those that were elliptical and rounded at both ends, there were others that were noticeably pointed at one end. They were conspicuously biguttulate and measured 5.2-7.5 x 2.2-2.8 μ. Sections of the ectostromatic bodies showed that the conidia had been proliferated from the hymenial layer lining the enclosed locules.

The fungus isolated from stems in categories (a) and (b) is obviously homothallic. In all of the isolates perithecial development is consistently and markedly of the cespitose type (Fig. 8). In these respects as well as otherwise morphologically, it is undoubtedly identical with the fungus regarded by Welch and Gilman (5) to be D. phaseolorum var. batatatis.

The phenomenon in Diaporthe of conidia being borne outside of a pycnidium, as with isolates of Group 2, is apparently not without precedent. According to Gwynne-Vaughan and Barnes (1) who include the genera Valsa and Diaporthe in the family Valsaceae of the Sphaeriales, "Conidia are often present, borne on free conidiophores or produced within pycnidia."

In describing D. phaseolorum var. sojae, Luttrell (3) pointed out that "spores intermediate between typical stylospores and typical pycnospores occur frequently." In describing the conidial connections of D. phaseolorum var. batatatis, Wehmeyer (4) notes that, "Club shaped bodies, cylindric, swollen at one end, straight or irregularly curved, 6-15 μ long also found (probably intermediate forms between alpha and beta conidia)." These bodies which measured up to 16.3 μ in length and 2.1 μ wide were frequently seen by the writer in mounts from isolates of all three groups.

From three isolates of Group 3, each of which produced both the perfect and the imperfect stage, subcultures of monoascospore and of monoconidium origin were made. Both sets of cultures produced perithecia in profusion, thus proving that, reproductively, conidia have the same potentiality as ascospores.

Categories (d) and (e): Monoascospore cultures derived from perithecia on each of the five stems in these two categories, all gave rise to Phomopsis isolates. Monoconidium cultures of these five isolates have been compared on potato dextrose agar medium and on steamed soybean stems. They vary in their ability to produce pycnidia, one of the five producing these bodies slowly and sparsely, the others more quickly and abundantly; otherwise they resemble one another closely. Because these isolates are indistinguishable morphologically from the Phomopsis of the type connected by Lehman (2) to D. sojae (later reduced by Wehmeyer (4) to a variety of D. phaseolorum), they are considered to be the imperfect stage of that organism, that is, D. phaseolorum var. sojae. The perithecia as they occurred on the stems from which the isolates were obtained, the asci, and the ascospores also conformed to the description of D. phaseolorum var. sojae. Presumably, the fungus is heterothallic but to date the five pycnidial isolates when paired on soybean stems have failed to give rise to a perfect stage. Their pathogenic capabilities will be tested during the coming summer.

DISCUSSION

As will have been noted above, a number of different investigators including Lehman (2), Luttrell (3), and Welch and Gilman (5) have studied the complex of pod and stem blight and stem canker or the fungi associated with it. Mycologically, it is difficult to compare the findings of the present study with those of Lehman and of Luttrell because those investigators did not work with single-spore cultures. The present studies can, however, be compared with those of Welch and Gilman because in both all isolates were of single-spore origin. Welch and Gilman were able to differentiate between two members of the genus Diaporthe on the basis of sexuality, morphology, and pathogenic capability. One organism, regarded by them to be D. phaseolorum var. batatatis, was homothallic, produced its perithecia in cespitose clusters, and was actively parasitic; the other, recognized as D. phaseolorum var. sojae, was heterothallic, produced scattered, single perithecia, and was less pathogenic. There is little doubt that the Diaporthes encountered in the present studies are similar in most respects to those studied by Welch and Gilman. In proving the heterothallic nature of one of the Diaporthes of the Iowa material, those investigators have succeeded where the present author has failed. This failure may probably be attributed to the fact that to date only five pycnidial isolates have been available for pairing. As it has been shown by the writer that a genetic connection exists between these five Phomopsis isolates and one of the Ontario Diaporthes, presumptive evidence is strong that this member of the genus is heterothallic. Welch and Gilman were also able to distinguish between the two Iowa Diaporthes on the basis of a clearcut difference in type of perithecial development, the one producing these bodies scattered and singly, the other in cespitose groups. The present author has not yet succeeded in establishing such a morphological basis for the ready recognition of and the differentiation between the Ontario Diaporthes. The presumably heterothallic form has been isolated from only five of the 1046 stems involved in the studies. Two of the five stems showed a single perithecium each, the other three having perithecia definitely intermixed with pycnidia. The finding by the writer of an imperfect stage of the homothallic Ontario Diaporthe is a discovery not reported by Welch and Gilman. It may be presumed either that the Iowa isolates, like some of the Ontario isolates, did not form such a stage, or that, though present in their cultures, it escaped their observation. The latter possibility might easily be the case especially with regard to the isolates which produced conidia apparently on the mycelium. It was only after the most careful examination, often of a succession of mycelial mounts from a given culture, that the presence of conidia was definitely established. The conidium-producing ectostromatic bodies occurring in other of the isolates, though less difficult to detect, had also to be watched for carefully.

An attempt to identify with certainty the Ontario Diaporthes has not yet been made. It had been planned to do so if the pairing of the five Phomopsis isolates of the presumably heterothallic form had resulted in the production of a perfect stage. As this did not occur, it has not yet been possible to compare critically in culture, the morphology (particularly that of the perithecia) of the isolates of the apparently two different forms. Meanwhile, the literature particularly relevant to the identification of Diaporthe spp. pathogenic to the soybean has been consulted and compared. In this connection a seeming discrepancy has attracted the attention of the writer. It centers on Welch and Gilman's (5) identification of their heterothallic Diaporthe as D. phaseolorum var. sojae. Those investigators say "The heterothallic or single perithecial type of the Iowa material closely resembles the description given by Lehman both in its gross appearance in the field and in culture..... In both natural and cultural material the perithecia were borne singly on an effuse stroma." Yet, Lehman (2) says of the fungus he named as D. sojae, "In culture on sterile soybean petioles, the perithecia are black and are rendered conspicuous by the tendency to form in clusters of 3-15 individuals." Obviously, in culture at least, Lehman's fungus displayed the cespitose type of perithecial development. It is unfortunate that Wolf and Lehman (6) did not give a description of the perfect stage of D. sojae as it was found in nature in 1924. The above and other considerations including the finding by the writer of an imperfect stage of the Ontario homothallic Diaporthe of the cespitose perithecial type, suggest that further clarification of the Diaporthe sp. or spp. that are pathogenic to the soybean may still be desirable.

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PHYSIOLOGIC RACES OF PUCCINIA RUBIGO-VERA TRITICI IN THE UNITED STATES IN 1953

C. O. Johnston and M. N. Levine

A large number of collections of leaf rust from wheat fields in various parts of the United States were received at the Kansas and Minnesota rust laboratories in 1953. It was possible to culture and determine the physiologic race content of 248 of those collections. They came from 26 States, representing all of the large geographic areas except the New England and certain adjacent Northeastern States. They yielded a total of 844 isolates, consisting of 28 different physiologic races of which only 15 were of major importance and comprised more than 1 percent each of the total number of isolates. The remaining 14 races were isolated only a few times each and in every case comprised less than 1 percent of the total number of isolates. These therefore, are considered to have been of minor importance in 1953.

The races of major importance are shown in Table 1. They represent 96.8 percent of all isolates. Race 5, constituting 28.4 percent of the total isolates, was by far the most prevalent race. It was isolated from collections from each of the 26 States. This race, therefore, was the dominant one in the United States in 1953, showing an increase of 7.3 percent over its prevalence in 1952. Race 15, representing 17.3 percent of all isolates, was second in importance. It was isolated from collections from all but 5 States and increased 1.0 percent over its prevalence in 1952.

Race 105 was third in prevalence, representing 8.4 percent of all isolates. If the similar races 6, 28, and 126 are considered with race 105 they represent a total of 16.3 percent of all isolates. Race 105 was present in all except the northwestern and southwestern areas. It was especially prevalent in Alabama, Oklahoma, Kansas, and North Dakota.

Race 35, occupying fourth place in order of prevalence, is of special interest, particularly if it is considered in connection with races 21, 54, and 122 which are similar to it. Races 35 and 122 apparently are of an aggresive nature, since they attack most of the differential varieties and some other varieties known to be resistant to other races. Both of these increased in prevalence in 1953 although the increase was only slight for race 122. They were most abundant in the Southeastern States, Kansas, and Texas. They should be given careful consideration in programs of breeding for leaf rust resistance because of their versatility and currently increasing abundance.

As usual, race 58 was more abundant around the Great Lakes, along the southern Atlantic coast, and around the Gulf coast than elsewhere. Race 93 was more prevalent in the Southeastern States than in other areas. Race 11, which still is the dominant race in Mexico, was much more prevalent in Pacific Coast States than elsewhere, although it also occurred in moderate amounts in Texas, Florida, Virginia, and North Dakota, and in small amounts in Georgia, Mississippi, Kansas, Nebraska, Iowa, and Minnesota in 1953. There is little to prove that race 11 is moving out of Mexico into the United States in amounts of any importance.

The distribution and prevalence of the 14 major races is shown in Table 2. The most interesting thing about this group of races is the occurrence of race 9 among them. This race, which formerly was the dominant race of leaf rust in the United States, was sixteenth in prevalence in 1953, representing only 0.6 percent of the total number of isolates. Even when the similar races 10, 13, 19, and 20 are added to race 9, this group represented only 3.6 percent of all isolates in 1953. The decline in abundance of race 9 and its related races in recent years was probably brought about by changes in the varieties of wheat grown on large acreages.

Table 1. Physiologic races of Puccinia rubigo-vera tritici of major importance isolated from collections made on wheat in various States of the United States in 1953.

Geographic and crop area, and State	Frequency distribution of physiologic races isolated — Physiologic race number															Major races — Total no.	
	2	5	6	11	15	19	20	28	35	52	58	93	105	122	126	Isolates	Race
NORTHEASTERN, SOFT WINTER																	
Michigan											6	1	3			10	3
Illinois		1			1				2		2		2		4	12	6
Missouri		2														2	1
SOUTHEASTERN, SOFT WINTER																	
Alabama		20			12	1	1		2			4	12	4	6	62	9
Arkansas		1	1		3											5	3
Florida		33		3	4				3		1		1	1	1	47	8
Georgia		14		1	1	3			4			3	2	17		45	8
Mississippi		5		2	7				1		5		2		1	23	7
North Carolina		1		1	1						7		3			13	5
Tennessee		1										2		3		6	3
South Carolina		10			12				7		7		2	3	2	43	8
Virginia		5		4	5				6		5	2	1	5	3	36	9
CENTRAL, HARD RED WINTER																	
Colorado		4			2											6	2
Kansas		28	4	2	17	1	3	2	13		3	1	12	16	6	108	13
Nebraska		2		1	1								1			5	4
Oklahoma		4	6		1	3	1	1				1	8	2	1	28	10
Texas		30	3	6	7		1		7		7		2	3	2	68	10
Wyoming		1														1	1
NORTHCENTRAL, HARD RED SPRING																	
Iowa		14		1	7	1	1	1	3		1				1	30	9
Minnesota	7	13	1	1	24			1	3	3	1		3	3	1	61	12
Montana	3	4			7			3		4						21	5
North Dakota	9	37		3	27	4	3	2	8	7	1		14	6	7	128	13
South Dakota	2	3			5											10	3
Wisconsin		6	1		2			2	2		1		3		3	20	8
NORTHWESTERN, WHITE WINTER																	
Washington		1		4										1	1	7	4
SOUTHWESTERN, WHITE SPRING																	
California				20												20	1
Total isolates	21	240	16	49	146	13	10	12	61	14	47	14	71	64	39	817	15
Percent of total isolates	2.5	28.4	1.9	5.8	17.3	1.5	1.2	1.4	7.2	1.7	5.6	1.7	8.4	7.6	4.6	96.8	

Table 2. Physiologic races of Puccinia rubigo-vera tritici of minor importance isolated from collections made on wheat in various parts of the United States in 1953.

Geographic and crop area, and State	Frequency distribution of physiologic races isolated — Physiologic race number														Total no.	
	1	9	10	13	16	21	32	38	45	50	54	76	127	131	Isolates	Races
SOUTHEASTERN, SOFT WINTER																
Florida	1										1				2	2
South Carolina														1	1	1
CENTRAL, HARD RED WINTER																
Kansas		2				1			1	1				1	6	5
Oklahoma		3	2												5	2
Texas				1		1									2	2
NORTH CENTRAL, HARD RED SPRING																
Minnesota					2		1								3	2
Montana							1						1		2	2
North Dakota								1				1	2		4	3
NORTHWESTERN, WHITE WINTER																
Washington	1													1	2	2
Total number isolates	2	5	2	1	2	2	2	1	1	1	1	1	3	3	27	14
Percent of total isolates	0.2	0.6	0.2	0.1	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.4	0.4	3.2	

FIELD CROPS RESEARCH BRANCH, AGRICULTURAL RESEARCH SERVICE, U. S. DEPARTMENT OF AGRICULTURE, IN COOPERATION WITH AGRICULTURAL EXPERIMENT STATIONS OF KANSAS AND MINNESOTA

PHYSIOLOGIC RACES OF CROWN RUST OF OATS IDENTIFIED IN 1953[1]

M. D. Simons

The advantages of the new set of 10 differential varieties of oats over the old standard set of 13 varieties for identifying races, as well as descriptions of the first 59 races of crown rust identified on the new set, will appear in another paper[2]. Since the first 59 were described, 16 previously undescribed races (Table 1) have been discovered by various investigators and brought to the attention of the writer.

Races 260 through 263 were identified by Vallega and Cenoz[3] in Argentina. Race 260 attacks Landhafer. Races 261, 262, and 263 parasitize both Landhafer and Santa Fe. Race 262 has an unusually wide host range, Victoria being the only variety of the new set of differentials resistant to it.

Races 264 and 270 were described by Wahl[4] in Israel. All 10 differentials except Saia are susceptible to race 264, while all but Bond and Saia are susceptible to race 270. Races 265 through 269 were identified by Lagos[5], who was then working in Brazil. Race 265 attacks both Landhafer and Santa Fe. None of the others reported by Lagos attack either of these varieties.

From material collected in Wales, Griffiths[6] isolated races 271 through 275. None of these races attack either Landhafer or Santa Fe but Ukraine is susceptible to all of them.

All collections of crown rust received at Ames, Iowa, during 1953 were identified on the new set of 10 differential varieties. A total of 18 races were identified among the 530 isolates obtained from oats in the United States and Canada (Table 2). As in the past few years, race 202 predominated, accounting for 45 percent of the total number of isolates identified. Anthony, Appler, and Bond are susceptible to race 202, while the remaining differential varieties, Victoria, Landhafer, Santa Fe, Ukraine, Trispernia, Bondvic, and Saia, are resistant.

Race 203 was second in importance, comprising 15 percent of the isolates. This race differs from race 202 only in its ability to parasitize Ukraine. Race 213, third most common, accounted for 14 percent of all isolates. It differs from race 202 only in its ability to parasitize Victoria. Neither race 203 or 213 showed an appreciable change in prevalence as compared with 1952.

Race 241 was isolated 32 times and appears to be increasing in prevalence. It probably does not represent any special menace as it attacks none of the newer sources of resistance.

Possibly the most significant development to come out of the 1953 race identification work was the identification of race 263, which appeared in two collections from Manitoba[7]. This race attacks Landhafer, Santa Fe, Trispernia, and Bondvic. These four varieties, however, were resistant to all other collections of crown rust tested in 1953. It is interesting to note that a fairly large number of collections were received on leaves of these varieties, but that this material did not infect seedling plants of the same varieties under greenhouse conditions at moderate temperature.

Ninety-one percent of the total number of isolates identified attacked Bond, which represents a decrease of these races as compared with their prevalence the last few years. A good share of those that did not attack Bond were either race 258 or 259. It is certain that these two

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[1] Cooperative investigation between the Field Crops Research Branch, Agricultural Research Service, U. S. Department of Agriculture, and the Iowa Agricultural Experiment Station. Journal paper No. J-2565 of the Iowa Agricultural Experiment Station, Ames, Iowa, Project No. 1176. The writer wishes to acknowledge his indebtedness to the investigators in other countries who have generously made their data available, and to those in the United States who have supplied crown rust collections for identification.

[2] Simons, M. D., and H. C. Murphy. 1954. A comparison of the relative efficiency of certain combinations of oat varieties in differentiating races of crown rust. U. S. Dept. Agr. Tech. Bul. (In manuscript).

[3] Unpublished data furnished by J. Vallega and H. Cenoz, 1953.

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[5] Unpublished data furnished by M. B. Lagos, 1953.

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Table 1. Reaction[a] of the new set of 10 differential varieties of oats in the seedling stage to 16 races of crown rust.

Race[b]	Differential variety and variety number									
	Anthony	Victoria	Appler	Bond	Landhafer	Santa Fe	Ukraine	Trispernia	Bondvic	Saia
	101	102	103	104	105	106	107	108	109	110
	Average reaction of differential varieties									
260	S	R	S	R	S	R	R	R	R	R
261	S	R	S	R	S	S	R	R	R	R
262	S	R	S	S	S	S	S	S	S	S
263	S	R	S	S	S	S	R	S	S	R
264	S	S	S	S	S	S	S	S	S	R
265	R	R	S	S	S	S	R	S	S	R
266	R	R	S	R	R	R	S	R	S	R
267	R	R	S	R	R	R	R	S	S	S
268	S	R	S	R	R	R	S	R	S	R
269	S	S	S	R	R	R	S	S	S	R
270	S	S	S	R	S	S	S	S	S	R
271	S	R	R	R	R	R	S	Int	R	S
272	R	R	S	R	R	R	S	R	R	S
273	Int	R	S	R	R	R	S	S	R	S
274	R	S	S	S	R	R	S	R	R	R
275	R	R	S	S	R	R	S	R	R	S

[a] "R" indicates that the variety is resistant (infection types I, O, 1, and 2) to the race; "Int" indicates that the reaction of the variety to the race cannot be clearly classified as resistant or susceptible; "S" (infection types 3 and 4) indicates susceptibility.

[b] Races were first identified as follows: races 260 through 263 by Vallega and Cenoz (footnote 3); race 264 by Wahl (footnote 4); races 265 through 269 by Lagos (footnote 5); race 270 by Wahl (footnote 4); and races 271 through 275 by Griffiths (footnote 6).

Table 2. Physiologic races of Puccinia coronata avenae isolated from oats in

Table 2. Physiologic races of Puccinia coronata avenae isolated from oats in 1953.

Area and location	Prevalence and distribution of physiologic races																		Total	
	201	202	203	205	213	216	226	227	231	232	235	237	239	241	258	259	263	274	Isolates	Races
NORTH CENTRAL																				
Illinois		1	1		1	1													4	4
Iowa		48	19	7	8	11	1			1				10	1	3		1	110	11
Kansas		1												1					2	2
Manitoba			1	2			1	1	1	1				1	1		2		11	9
Michigan	1	5	3			1													10	4
Minnesota		6	5		1									1					13	4
Missouri		2						1						1					4	3
Nebraska		1	1																2	2
North Dakota		10	4	2		2			1		1	1		3	1				25	9
Ohio		8	4		1									2					15	4
South Dakota		3	5	1										1					10	4
Wisconsin		6					1							1	1	1			10	5
EASTERN																				
Maine		3			2										1				6	3
Pennsylvania		1																	1	1
SOUTHERN																				
Alabama	1	29	8	2	11	2		1						3	1	1			59	10
Arkansas		2	1																3	2
Florida		47	9	1	31	10									8	2			108	7
Georgia		13	4		7	1						1		1	1				28	7
Kentucky		2	2		1	1													6	4
Louisiana		5			2									2					9	3
Mississippi		5	3	2	1	2									2				15	6
North Carolina		2	1											1					4	3
Oklahoma		3																	3	1
South Carolina		2	2	1		1						2				1			9	6
Tennessee		1																	1	1
Texas		27	6	2	4	1		1		1				2		2			46	9
Virginia	1	4	1	1	1								1	2					11	7
West Virginia		1		1	1							1							4	4
WESTERN																				
Wyoming		1																	1	1
Total isolates	3	239	80	22	72	33	3	4	2	3	1	5	1	32	17	10	2	1	530	18
Percent	.6	45.1	15.1	4.2	13.6	6.2	.6	.8	.4	.6	.2	.9	.2	6.0	3.2	1.9	.4			
Locations	3	28	19	11	14	11	3	4	2	3	1	4	1	15	9	6	1			
Areas	2	4	2	2	3	2	1	2	1	2	1	2	1	2	3	2	1			

Table 3. Physiologic races of Puccinia coronata avenae isolated from Rhamnus spp. in 1953

State	Prevalence and distribution of physiologic races											Total	
	201	202	203	205	213	214	216	226	227	235	241	Isolates	Races
Illinois		2	1									3	2
Iowa	1	44	23	4	3	1	2	1	1	1	8	89	11
Minnesota		3									1	4	2
Nebraska		1										1	1
Wisconsin		2	1	2			1				3	9	5
Total	1	52	25	6	3	1	3	1	1	1	12	106	11
Percent	0.9	49.1	23.6	5.7	2.8	0.9	2.8	0.9	0.9	0.9	11.3		

races do not correspond to old races such as 1 and 6, which do not attack Bond, since they attack Victoria while races 1 and 6 did not.

The various races attacking Victoria (213, 216, 258, and 259) constituted one-fourth of the total. This represents a small increase as compared with 1952.

One-hundred-six isolates of crown rust from Rhamnus spp. were identified in 1953 (Table 3). The big majority of these were from field collections made from the cultivated buckthorn, Rhamnus cathartica. A few were from the wild species, R. lanceolata, and several were from other species grown and infected in the greenhouse with naturally produced telial material that had over-wintered in the field.

Race 202 made up one-half of the total 106 isolates identified. Race 203 was second in prevalence accounting for about one-fourth of the total. The previously uncommon race 241, which attacks Anthony, Appler, Bond, Ukraine, and Saia, was third, making up 11 percent of the total. Race 205, which also attacks Saia but does not attack Ukraine, was next in importance.

Races attacking Victoria constituted only 6 percent of the total, while races attacking Ukraine made up 38 percent of the total, and races attacking Saia, about 17 percent. The relative prevalence of the races attacking these varieties differs markedly from the figures obtained in previous years, when races from buckthorn attacking Victoria were more common than those attacking Ukraine or Saia.

FIELD CROPS RESEARCH BRANCH, AGRICULTURAL RESEARCH SERVICE, U. S. DEPARTMENT OF AGRICULTURE, AND IOWA AGRICULTURAL EXPERIMENT STATION, AMES, IOWA

GENETIC-CONTROLLED CARBOHYDRATE AND SOLUBLE NITROGEN COMBINATIONS IN PLANT TISSUES CAUSING RESISTANCE TO THE BACTERIAL BLIGHT DISEASE OF COTTON[1]

L. S. Bird[2]

Natural plant resistance is the only known method for adequately controlling the bacterial blight disease of cotton caused by Xanthomonas malvacearum (E. F. Sm.) Dowson. For this reason, the development of resistant varieties has received considerable attention during the past decade. A number of genetic factors which cause plants to resist X. malvacearum are known. Among the more important ones are Knight's (5, 7) B_2, B_3, and B_6 factors, and Simpson and Weindling's (8) Stoneville 20 factor (designated by Knight (6) as B_7). In the United States, Stoneville 20 has been the principal source of resistance used in a number of programs for developing resistant varieties.

The physiology of resistance to bacterial blight is a natural curiosity and an understanding of it would aid considerably in developing resistant varieties of cotton. Thiers and Blank (9) found no evidence of morphological resistance after making histological investigations with Stoneville 20 resistant material. Hughes and Fowler (4), working with material with Knight's B_2 and B_3 factors, found a high glucose content of the leaves associated with resistance for the first 90 days after planting. The purpose of this paper is to summarize briefly current investigations which are being made at College Station, Texas, to ascertain the nature of resistance to bacterial blight of cotton.

MATERIALS AND METHODS

Deltapine and Stoneville 2B variety types with the Stoneville 20 factors for resistance were used throughout these investigations. All plants from which leaf samples were taken were previously inoculated with Xanthomonas malvacearum by using the method of inoculation reported by Bird and Blank (1). Three weeks after inoculation each plant was assigned a disease grade by using the grading shown in Figure 1.

Leaf samples were taken by collecting leaf blades from the ten youngest leaves on the main stem. Dextrose, sucrose, starch, and soluble nitrogen were determined according to the methods outlined by Ergle (3).

EXPERIMENTAL

The Relation Between Carbohydrates and Soluble Nitrogen and Disease Resistance in Greenhouse and Field Grown Plants

Carbohydrate fractions were determined in a complete diurnal sampling study which was made with resistant and susceptible plants grown in the greenhouse during the winter of 1953-54. The results are given in Table 1. With the Stoneville 2B variety the average dextrose, sucrose, starch, and total carbohydrates (sum of dextrose, sucrose, and starch) were higher in the resistant strain than in the susceptible strain. In observing fractions for the various sampling times it can be seen that starch was consistently higher in the resistant material. With Deltapine the resistant strain was higher in average starch and total carbohydrates and lower in dextrose and sucrose than the susceptible strain. Also, the resistant Deltapine strain, except for the 3 a.m. sampling, was consistently higher in starch.

Leaf samples from 20 individual field-grown plants from F_2 populations of Stoneville 2B and Deltapine variety types which were segregating for resistance were analyzed for dextrose, sucrose, starch, and soluble nitrogen. None of the carbohydrate fractions or soluble nitrogen showed any relationship with resistance. The ratios of the various carbohydrate fractions with

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1 The data discussed in this paper will form a portion of a dissertation which will be presented to the Graduate School of the A & M College of Texas as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

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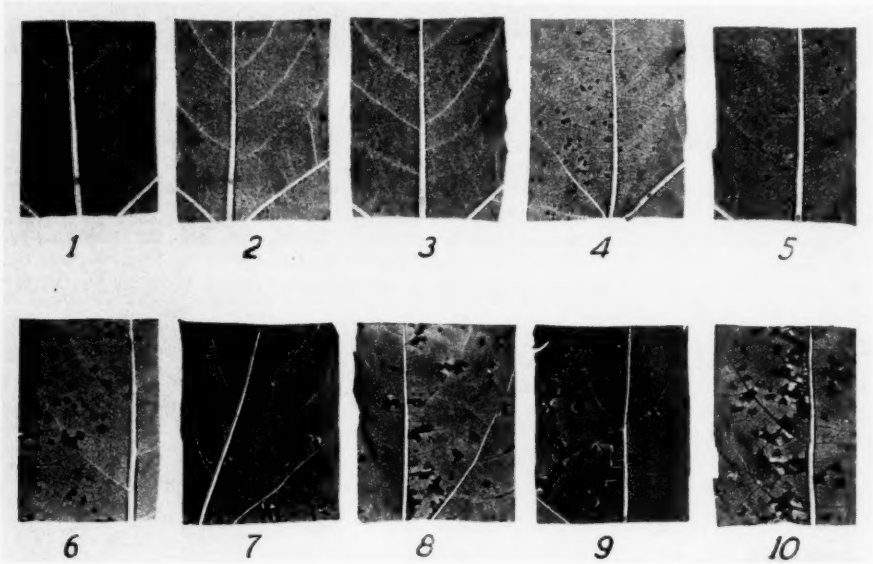

FIGURE 1. Disease grading system for cotton bacterial blight. Grades: 1 -- no infection. 2 -- lesions about 0.5 mm. in size, round and raised, brown, never angular, wet or coalesced. 3 -- intermediate to grades 2 and 4. 4 -- lesions about 1 to 1.5 mm. in size, round to slightly angular and sunken, never coalesced. 5 -- intermediate between 4 and 6. 6 -- lesions 2 to 3 mm. in size, angular, and sunken, some coalescing. 7 -- lesions 2 to 5 mm. in size, angular with coalescing, exudate present. 8 -- intermediate to 7 and 9. 9 -- lesions 3 to 7 mm. in size, frequent coalescing, exudate present. 10 -- lesions 3 to 10 mm. in size, extensive coalescing, exudate present.

soluble nitrogen are given in Table 2. The data were transformed to angles, and correlations between the ratios and disease grades of the plants were made. These are given in the extreme right column of the table. Although the correlation values are not significant they are much higher than any which were obtained in earlier studies with carbohydrates alone. This is especially true for the Deltapine material. Because of this the relationship between carbohydrate-soluble nitrogen ratios and resistance to bacterial blight of cotton was further investigated.

Growth of Xanthomonas malvacearum as Influenced by Various Carbohydrate/Nitrogen Ratios in Agar Culture

The influence of various carbohydrate and nitrogen combinations on the growth of X. malvacearum in vitro was ascertained. Agar media were used in which dextrose was the carbohydrate source and nitrogen was supplied by either sodium nitrate, calcium nitrate, or asparagine. The pH of the media was adjusted to give a pH of 6.0 after autoclaving.

The first results showed that low dextrose/nitrogen ratios completely inhibited growth. Later results indicated that a low ratio was not the critical factor. At 3.5 percent dextrose and 0.40 percent nitrogen the growth of X. malvacearum was completely inhibited while at 10 percent dextrose it took only 0.06 percent nitrogen to suppress growth completely. Thus, as shown in Figure 2, combinations of dextrose and nitrogen which fall above the curve prevent growth while those which fall inside the curve do not. Further experiments showed that the

Table 1. Carbohydrate fractions for Xanthomonas malvacearum resistant and susceptible strains of Stoneville 2B and Deltapine cotton variety types, for eight sampling times during a 24-hour period.

Strains and carbohydrate fractions	Sampling time								
	3 a.m.	7 a.m.	9 a.m.	12 a.m.	2 p.m.	5 p.m.	7 p.m.	11 p.m.	Average
Resistant Stoneville 2B									
Dextrose	1.02	0.70	0.65	1.22	1.38	1.20	1.13	0.95	1.03
Sucrose	0.53	0.29	0.08	0.79	0.69	1.05	0.90	1.04	0.67
Starch	3.28	2.14	1.02	5.37	6.82	5.63	5.02	3.31	4.07
Total	4.83	3.13	1.74	7.38	8.89	7.88	7.05	5.30	5.78
Susceptible Stoneville 2B									
Dextrose	0.84	0.55	0.65	1.43	1.15	0.90	1.10	1.00	0.95
Sucrose	0.33	0.68	0.61	0.62	0.61	0.60	0.22	1.10	0.60
Starch	1.98	1.89	1.27	4.35	5.97	5.44	4.72	3.50	3.64
Total	3.15	3.12	2.53	6.40	7.73	6.94	6.04	4.60	5.06
Resistant Deltapine									
Dextrose	0.52	0.72	1.03	1.90	1.22	1.59	1.03	0.89	1.10
Sucrose	0.32	0.22	0.34	0.60	0.49	0.45	0.61	0.50	0.44
Starch	3.62	2.99	3.70	7.54	8.71	10.27	8.19	6.90	6.49
Total	4.46	3.93	5.07	10.04	10.42	12.31	9.83	8.29	8.04
Susceptible Deltapine									
Dextrose	0.85	0.57	1.02	1.49	1.42	1.96	1.57	0.76	1.21
Sucrose	0.60	0.65	0.93	0.69	0.61	0.87	0.85	0.79	0.75
Starch	3.90	1.97	2.55	4.84	5.68	8.40	7.02	5.54	4.99
Total	5.35	3.19	4.50	7.02	7.71	11.23	9.45	7.09	6.94

same type curve was obtained when dextrose was held constant and nitrogen was varied. These results were obtained with both sodium nitrate and calcium nitrate as the source of nitrogen.

When asparagine was used as the source of nitrogen, growth was reduced in both amount and rate. Also, with asparagine, it took twice as much nitrogen to retard growth as it did with sodium nitrate.

These results were obtained with agar media with only dextrose and the source of nitrogen added. Growth of the causal organism was also completely inhibited in the same manner by adding nitrogen to potato-carrot dextrose agar, which is an excellent medium for culturing X. malvacearum.

Growth of the organism was retarded but not completely inhibited in a medium containing 14 percent dextrose.

The growth of two isolates of X. malvacearum with different pathogenicity levels was compared on media which ranged from a favorable dextrose-nitrogen combination to an unfavorable combination. The growth of the isolate with a low pathogenicity level was always completely inhibited in a combination in which the isolate with a higher pathogenicity level would grow. These results suggest that the pathogenicity of races of the causal organism is associated with in vitro inhibition of growth by unfavorable carbohydrate-nitrogen combinations.

The above results showed that the growth of X. malvacearum was inhibited by an unfavorable balance of dextrose and nitrogen. The general relationship between amounts of dextrose and nitrogen needed for inhibiting growth was negative.

Table 2. Relationship of carbohydrate/soluble nitrogen ratios to disease grades of individual F_2 plants segregating for resistance to the bacterial blight disease of cotton in Stoneville 2B and Deltapine variety types.

Carbohydrate soluble nitrogen ratios	Disease grades 1	2	3	4	5	6	7	8	9	10	Correlations with disease grades
Stoneville F_2											
No. of plants sampled			3	5	1	3	2				
Average percent soluble nitrogen			0.42	0.46	0.43	0.30	0.43				
Dextrose/sol. N			2.91	3.00	3.72	3.97	2.33				+0.10
Sucrose/sol. N			2.43	1.74	1.86	4.07	2.74				+0.33
Starch/sol. N			15.55	14.96	15.58	25.30	16.49				+0.34
Sum of CHO/sol. N			20.88	19.70	21.16	33.33	21.56				+0.28
Deltapine F_2											
No. of plants sampled	1	1		1	1		1		1		
Percent soluble nitrogen	0.39	0.57		0.57	0.48		0.50		0.45		
Dextrose/sol. N	2.00	3.68		2.04	3.46		2.44		2.91		+0.03
Sucrose/sol. N	1.92	0.60		0.86	2.21		1.58		2.20		+0.46
Starch/sol. N	6.36	8.23		8.23	8.40		7.06		10.71		+0.63
Sum of CHO/sol. N	10.28	12.51		11.12	14.06		11.62		15.82		+0.65

The Influence of Various Carbohydrate-Nitrogen Combinations on Resistance to Xanthomonas malvacearum as Indicated by Excised Leaves

Excised leaves were used to ascertain the effects of various carbohydrate-nitrogen combinations on resistance. Leaves on resistant and susceptible plants were inoculated with X. malvacearum. Three days after inoculation the leaves were cut off at the stems and the petioles were placed in the treatment solutions. Dextrose was the carbohydrate source while sodium nitrate was the source of nitrogen.

Leaves from resistant plants which were placed in solutions with a favorable combination for the growth of the organism gave a susceptible reaction while leaves from the same plant which were placed in solutions with an unfavorable combination remained resistant. Also, when leaves from susceptible plants were placed in favorable solutions, a susceptible reaction occurred, but a resistant reaction occurred on the leaves from the same plants which were placed in unfavorable solutions. Such results suggest that a genetic-controlled physiological mechanism which causes an unfavorable carbohydrate-nitrogen balance to be established in cotton leaves causes such leaves to resist infection by X. malvacearum.

In greenhouse studies plants with Stoneville 20 factors which were weak in resistance became highly resistant after being side-dressed with ammonium nitrate, whereas the check plants which received no nitrogen remained weak in resistance.

DISCUSSION

The results obtained with eight samples taken during a 24-hour period showed that resistant lines of the Stoneville 2B and Deltapine variety types had higher levels of total carbohydrates than did susceptible lines. The difference appeared to be primarily due to the starch fraction. However, the small differences of 0.72 to 1.10 percent are probably not great enough to be the only factor which causes plants to be resistant or susceptible. This fact is apparent when the resistant and susceptible lines of the two variety types are compared. The Deltapine line has greater natural tolerance to X. malvacearum than does Stoneville 2B. It will be noted that the total carbohydrate levels for the susceptible varieties have the same relationship with the more tolerant Deltapine having the higher level. The same holds true when the resistant lines of the two varieties are compared. However, the total carbohydrate level of 5.78 percent for the resistant Stoneville 2B line is lower than the level of 6.94 percent for the susceptible Deltapine line. These facts suggest that the carbohydrate level within a variety is only one of possible several factors associated with resistance.

The determination of percent carbohydrates and soluble nitrogen in leaf samples, from individual plants of a F_2 population which was segregating for resistance, suggested that resistance was due to a ratio of these two factors.

In vitro studies of the causal organism showed that it could not grow in media with unfavorable carbohydrate/nitrogen ratios. The results given in Figure 2 suggested that the actual carbohydrate/nitrogen ratio was not critical but that the balance between carbohydrates and nitrogen was. The relationship between carbohydrate and nitrogen is negative, thus requiring higher levels of nitrogen to inhibit growth at low carbohydrate levels than is necessary at higher carbohydrate levels.

Assuming that the studies indicate a strong relationship between carbohydrate-soluble nitrogen combinations and resistance, it is enlightening to study the individual plant data with this in mind. In Figure 3, the total carbohydrate level is plotted against the soluble nitrogen level. With the Stoneville F_2, the average total carbohydrate and soluble nitrogen levels are used for each disease grade. The disease grade of each is given next to the plotted point on the graph. With the disease grading system, grades 1 to 4 are considered to be degrees of resistance and grades 5 to 10 degrees of tolerance and full susceptibility. Sections of the curve in Figure 3 for the corresponding carbohydrate levels are superimposed on the graph so as to separate, as much as possible, the plotted points into resistant and susceptible groups. This divides the plants generally as was expected with only two of the eleven being out of place.

Under the hypothesis that unfavorable carbohydrate-soluble nitrogen combinations in cotton leaves cause them to resist X. malvacearum, one would expect resistance to be poor in plants showing nitrogen deficiency. This has been observed where resistant plantings were satisfactory under favorable nitrogen but were classed as susceptible under low nitrogen conditions. Further evidence to support this was gained in the greenhouse where plants which were classified as having weak resistance became highly resistant after being side-dressed with nitrogen.

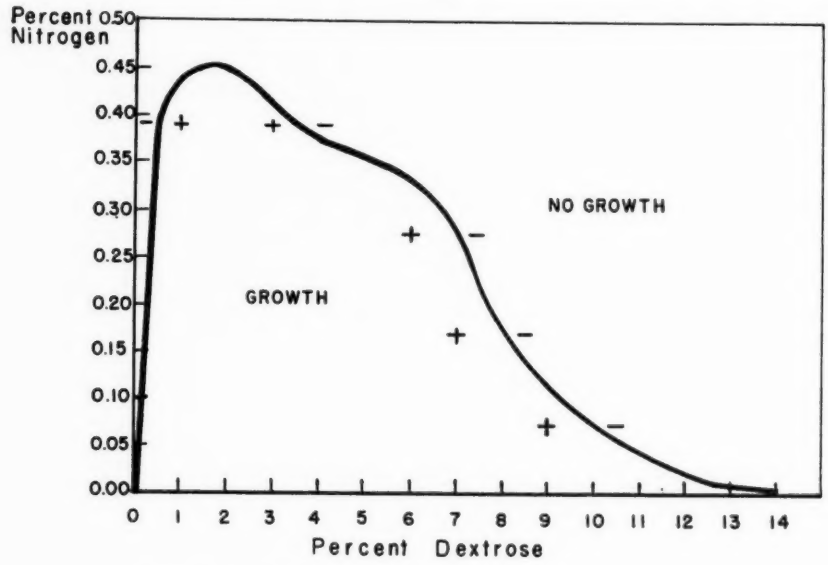

FIGURE 2. Growth of Xanthomonas malvacearum on agar media with various combinations of dextrose and nitrogen.

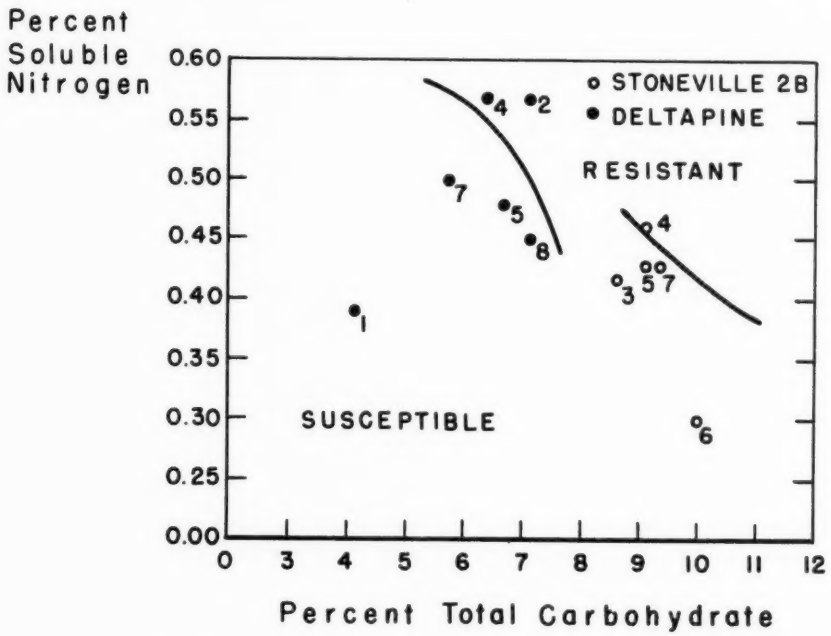

FIGURE 3. Soluble nitrogen and total carbohydrate of individual F_2 plants of Stoneville 2B and Deltapine types for each disease grade of cotton bacterial blight.

Under the hypothesis environmental conditions which would affect the carbohydrate-soluble nitrogen balance in the leaves would be expected to affect resistance. It has been observed that field plantings of resistant material growing under marginal soil moisture conditions were weak in resistance whereas those growing under favorable soil moisture conditions had satisfactory resistance. Eaton and Ergle (2) reported that low soil moisture conditions caused the total carbohydrate level of cotton leaves to decrease while at the same time soluble nitrogen increased. In Stoneville 2B, which has tolerance to bacterial blight, the carbohydrate reduction was proportionally about the same as the amount that nitrogen increased. By studying Figure 2 it can be seen that such a change in the carbohydrate-soluble nitrogen balance in the leaves could cause a shift from an unfavorable balance to a favorable one.

Under the above hypothesis, resistance would be caused by an increase in carbohydrates with soluble nitrogen remaining constant or an increase in soluble nitrogen with the carbohydrate remaining constant. Also, an increase at the same time in both carbohydrates and soluble nitrogen would create a balance which would inhibit the growth of X. malvacearum in tissues of the cotton plant.

The mechanism by which such carbohydrate-soluble nitrogen combinations are established in cotton leaves may be as follows: Genes for bacterial blight resistance could actually be genes which cause a more efficient carbohydrate synthesis thus causing resistant plants to have slightly higher carbohydrate levels. This was indicated in the diurnal studies where resistant plants have 0.72 to 1.10 percent more carbohydrates than susceptible plants of the same variety type. Assuming that the ability to synthesize protein remains the same and that the higher carbohydrate level forces amino acid production to a higher level, such a mechanism would cause resistant plants to have higher carbohydrate and soluble nitrogen levels. Such a mechanism in cotton leaves would create unfavorable carbohydrate-soluble nitrogen combinations which inhibit the growth of X. malvacearum.

Experiments for further testing the above developed hypothesis are underway.

SUMMARY

Strains with Stoneville 20 resistance were used in investigations to ascertain the nature of resistance to the bacterial blight disease of cotton. Carbohydrate determinations which were made with leaf samples taken from resistant and susceptible material at eight sampling times during a 24-hour period showed that resistant material had about 0.72 to 1.10 percent more total carbohydrate than susceptible material. The difference was primarily due to the starch fraction. Carbohydrate and soluble nitrogen determinations made with leaf samples taken from individual plants of a F_2 population which was segregating for resistance suggested that resistance was actually caused by a balance between these two factors.

In agar culture the growth of the causal organism was inhibited by unfavorable carbohydrate-nitrogen combinations. The relationship between carbohydrate and nitrogen to give unfavorable combinations was negative, thus requiring higher levels of nitrogen to inhibit growth at low carbohydrate levels than was necessary at higher carbohydrate levels. An increase in either carbohydrate or nitrogen with the other remaining constant, or an increase at the same time in both, inhibited growth.

Excised leaves from resistant plants, which had been inoculated with Xanthomonas malvacearum, gave susceptible reactions when placed in solutions with favorable carbohydrate-nitrogen combinations but such leaves remained resistant when placed in solutions with unfavorable combinations.

The results suggest that a genetic-controlled physiological mechanism which causes an unfavorable carbohydrate-nitrogen balance to be established in cotton leaves causes such leaves to resist infection by X. malvacearum.

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CONTROL OF TOBACCO WILDFIRE WITH STREPTOMYCIN SULFATE

H. E. Heggested and E. E. Clayton

Abstract

The antibiotic, streptomycin sulfate, has been found to give excellent control of the wildfire disease in tobacco plant beds. Spray, drench, and dust treatments were compared. Spray treatments were most effective and dust treatments least effective. The best spray treatment was streptomycin at rates of 200 and 400 parts per million. The streptomycin sprays gave better wildfire control than either Bordeaux mixture or fixed-copper spray or drench treatments. Plants treated with streptomycin have larger, more fibrous root systems than the copper-treated or than the surviving plants in the no-treatment plots. Applications were made in growers' beds that were badly affected by wildfire. Three weekly treatments resulted in striking recovery of the treated portions, while in the untreated portions of these beds wildfire continued to develop. Similar treatments of diseased beds were made by farmers with equally striking results. It appears that the antibiotic may be effective as an eradicant as well as a protectant. Tests in absence of disease to determine phytocidal levels showed that at 960 and 480 p.p.m. streptomycin sulfate caused leaf chlorosis, which became quite pronounced after three applications; however, even at these high rates, the chlorotic symptoms soon disappeared and the plants resumed normal growth.

Experiments were conducted to test the value of streptomycin in controlling wildfire (Pseudomonas tabaci) in tobacco plant beds. In recent years this disease has become more prevalent and destructive throughout the burley area. Plant stands are often greatly reduced, and, when not controlled, the disease is carried to the field on surviving plants resulting in early field development and often serious losses. Present control methods including both bordeaux "bluestone-lime" and fixed copper treatments combined with sanitation practices have not been satisfactory.

The series of 12 chemical treatments included in one experiment are listed in Table 1. Streptomycin sulfate was tested at rates of 100, 200, and 400 p.p.m. Treatments also included applications of Streptomycin chloride and an insoluble salt formulated to contain 10% streptomycin. The bordeaux and Tri-basic-copper sulfate, "fixed copper", treatments are those recommended for wildfire control in different areas. All spray treatments were applied at the rate of 10 gallons per 100 sq. yds. and the drench treatments were sprinkled at the rate of 25 gallons per 100 sq. yds. A wetting agent, Triton X-155, was added to all streptomycin treatments at 2 oz./100 gallon rate. For these tests, plants of Burley 1 were grown in flats in a plant bed with 1 inch by 8 inch board sides and with a cotton cover. Weather conditions were favorable for good stands and normal growth of plants.

Before seeding the flats, a suspension of wildfire bacteria was sprinkled over the soil. The first chemical treatments were applied April 12, when plants were in the two-leaf stage. Three additional applications of chemicals were made at weekly intervals. On April 21, one day after the second application, the small plants were spray-inoculated, using 500 c.c. of potato-dextrose broth culture in 2 liters of water. Weather following this inoculation was relatively dry and unfavorable for disease development. An additional inoculation was made April 29 after the third application of the chemicals. Conditions at this time remained favorable for the disease and heavy infection resulted in plots without chemical treatment and some of the other plots with inferior chemical treatments. Figure 1 shows the severe disease development and reduced stand of plants in Tri-basic-copper sulfate and "no-treatment" plots, as contrasted to excellent control of wildfire with streptomycin sprays.

Data were secured May 13 and 14 to determine percentage plants killed by wildfire, plants with wildfire toxin in the bud, and amount of leaf injury (disease index) to surviving plants (see Table 2). There was some variation between treatments in plant stand on April 22 (Table 2), at the time of first inoculation with wildfire; however, the differences between treatments were not significant, according to analysis of variance. These stand counts were later used as a basis for determining reduction in stand, and other data, following the spray inoculations. Apparently the soil inoculation before seeding was relatively ineffective. By May 13, as a result of the two spray inoculations made April 21 and 29, 35 percent of plants in the no-treatment plots were dead, 23 percent developed wildfire toxin in the bud, and the surviving plants showed

Table 1. Treatments used in experiment reported in Tables 2 and 3.

Treatments	Concentration	Application
1. Streptomycin So4 (Merck-STS)	100 p.p.m.	Spray
2.	200 p.p.m.	Spray
3.	400 p.p.m.	Spray
4.	100 p.p.m.	Sprinkle
5. Streptomycin Cl. (Agrimycin 200A)	200 p.p.m.	Spray
6. Streptomycin "Merck-STB" insoluble salt	100 p.p.m.	Spray
7.	100 p.p.m.	Sprinkle
8.	300 p.p.m.	Dust
9. Bordeaux	3-4-50	Sprinkle
10. Tri-basic-copper sulfate	3 lb/100 gal.	Sprinkle
11.	3 lb/100 gal.	Spray
12. Streptomycin So4 (Agrimycin 200C)	200 p.p.m.	Spray
13. No Chemical treatment	--	--

a disease index of 62. Best disease control resulted from the spray treatments numbers 2, 3, and 12, using streptomycin sulfate at rates of 200 and 400 p.p.m. There was no difference between results of treatment with streptomycin sulfate (200 p.p.m.) obtained from two different sources (treatments 2 and 12 respectively). Spray treatments consistently gave better control than sprinkle "drench" treatments. The streptomycin chloride and an insoluble salt formulation were inferior to streptomycin sulfate. The difference between disease indices 1.1 and 13.1 for sulfate and chloride forms respectively (100 p.p.m. rate) are significant. On the basis of disease indices all streptomycin treatments except the insoluble salt of streptomycin sprinkled and dusted were significantly better than any of the recommended copper treatments, numbers 9, 10, and 11. The streptomycin insoluble salt formulation applied as dust (300 p.p.m.) was inferior to either spray or sprinkle treatments.

The differences between bordeaux treatment 9 and Tri-basic-copper sulfate treatments 10 and 11 were highly significant. Tri-basic-copper sulfate resulted in approximately 20 percent more plants with toxin development in the bud than the bordeaux treatment.

It became apparent, while pulling the plants to obtain data on disease development, that plants treated with streptomycin for instance, with streptomycin sprays at 200 and 400 p.p.m. rate which gave good wildfire control, had larger and more fibrous roots than surviving plants in plots without chemical treatment and plots with fixed copper treatments. For data on root development, 10 of the largest plants from each plot were carefully removed in treatments 1 through 4, 9, 10, and 13. Roots were washed and dried, and weights of both shoots and roots taken. Table 3 shows dry weights of shoots and roots, The shoot-root ratio confirms the earlier observation that streptomycin treatments that controlled wildfire resulted in better root system development than either no treatment or copper treatments. The shoot-root ratios for plants in streptomycin plots sprayed at the 200 and 400 p.p.m. rates and sprinkled at 100 p.p.m. were significantly lower than for surviving plants nearly the same size in plots without chemical treatment. Examination of roots and the data in Table 3 suggest that severe wildfire development may cause appreciable injury to roots as well as tops. Plants with good fibrous root systems will, of course, survive the shock of transplanting much better than plants with poor root development; consequently, better root development following application of streptomycin sulfate could be an additional advantage from using this antibiotic to control wildfire in the plant beds.

For a further check on the value of streptomycin sulfate for wildfire control, 25 square yards or more of four different farm beds were sprayed at weekly intervals with 120 p.p.m. streptomycin, beginning April 6 and continuing for a total of five applications. By the end of

FIGURE 1. Control of wildfire with streptomycin sulfate spray, right; Tri-basic-copper sulfate spray, left; and no treatment, center. May 14, 1954.

Table 2. Comparison of streptomycin and recommended copper treatments for tobacco wildfire control in plant beds.

Treatment	Plant stand sq. ft. (April 22)	Plants killed May 13	Plants with toxin in bud May 13	Plants living with normal buds May 13	Disease index[a] on plants with normal buds May 13
	number	percent	percent	percent	index
1	65	3.7	0.9	95.4	4.7**
2	72	0.0	0.0	100.0*	1.1**
3	60	0.0	0.0	100.0*	1.1**
4	69	5.7	0.9	93.4	9.4**
5	54	2.3	3.5	94.2	13.1**
6	64	8.3	1.4	90.3	15.7**
7	65	8.3	3.5	88.2	26.3
8	77	26.0**	10.1	63.9**	44.2
9	65	6.7	7.5	85.8	35.8
10	71	20.3**	27.2**	52.5**	60.9**
11	68	14.3	26.5**	59.5**	53.7**
12	74	0.0	0.0	100.0*	0.6**
13	66	35.0**	22.9**	42.1**	62.0**
L.S.D. at 1%	NS	10.0	8.5	13.6	10.9
L.S.D. at 5%		13.6	11.5	18.5	14.8

[a] 0 = No disease; 100 = All leaves destroyed.

* Significant difference compared to bordeaux treatment.

** Highly significant difference compared to bordeaux treatment.

Notes: Three replications of each treatment.
Four applications of chemicals, April 12, 20, 27, and May 4.
Wildfire inoculation before seedling, and April 21, and 29.

Table 3. Influence of streptomycin and copper treatments upon the shoot-root ratio of tobacco plants inoculated with the wildfire bacterium. Chemical applied at weekly intervals, four applications. Duration of experiment 31 days.

	Treatment	Dry weight (10 plants)		
		Shoot	Root	Shoot/root ratio
		Grams	Grams	Ratio
1	Streptomycin 100 p.p.m. -- sprayed	3.83**	.29**	13.06
2	Streptomycin 200 p.p.m. -- sprayed	3.71**	.32**	11.57*
3	Streptomycin 400 p.p.m. -- sprayed	3.56*	.32**	11.31**
4	Streptomycin 100 p.p.m. -- sprinkled	3.60*	.29**	12.52*
9	Bordeaux 3-4-50 -- sprinkled	3.96**	.27**	14.67
10	Tri-basic Cu So4 3 lb./100 gal.-sprinkled	2.96	.20	14.89
13	No chemical treatment	2.54	.16	15.90
L.S.D. at 1 percent		.83	.07	3.14
L.S.D. at 5 percent		1.17	.10	4.41

*Significant difference compared to plants with no chemical treatment.

**Highly significant difference compared to plants with no chemical treatment.

Table 4. Wildfire control with streptomycin sulfate (200 p.p.m.) in tobacco plant beds when applications were started after disease appearance.

Replication[a]	Results of chemical treatment based upon					
	Plant stand (plants per sq. ft.)		Disease index[b]		Plants with wildfire toxin in bud	
	Strepto-mycin treated	No chemical treatment	Strepto-mycin treated	No chemical treatment	Strepto-mycin treated	No chemical treatment
	Number	Number	Index	Index	Percent	Percent
A	22.4	14.9	2.6	33.2	0	26.8
B	22.3	14.6	7.8	55.2	0	60.3
C	23.5	12.0	3.0	42.9	0	35.0
D	14.5	12.9	2.7	35.5	0	17.1
Average	20.7	13.6	4.0	41.7	0	34.8

[a] Each replication 50 sq. yds. Spray applications of streptomycin April 21, 27, May 4. Data collected May 12, 1954.

[b] 0 = No disease; 100 = All leaves destroyed.

the plant bed season, no wildfire had appeared in streptomycin-treated plots; whereas some wildfire occurred in parts of each bed not treated with streptomycin. Except for disease development there was no conspicuous difference in top growth of plants with and without streptomycin treatments. Sections of beds not treated with streptomycin had been treated by the grower with two or more applications of fixed copper treatments. Three of the growers noted better root systems on streptomycin-treated plants. One of the growers set out comparative plantings in the field and reported less replanting where streptomycin-treated plants were used. About one month after transplanting, streptomycin-treated plants in this field were more uniform in growth, and were generally slightly larger than plants in comparable rows set with untreated plants.

Effect of Treatment with Streptomycin after Disease Appearance

A grower near the Station reported on April 20 that wildfire was severe in several of his plant beds, 400 square yards being rated by him as a total loss. To test the value of streptomycin in controlling wildfire after appearance of the disease, this 400 square yards was divided into eight 50 square yard plots. Four of the plots were sprayed with streptomycin sulfate at the 200 p.p.m. rate, beginning April 21 and continuing for three weekly applications. The remaining four plots received no chemical treatment. The grower stated that all beds had been treated when plants were small with Tri-basic-copper sulfate drenches, according to recommendations.

Results of streptomycin treatments were striking (see Table 4). They indicated that the antibiotic may be effective as an eradicant, as well as a protectant. At the end of the three-week treatment period a third more plants were living in the treated plots than in the untreated check areas. No plants in treated plots showed toxin development in the bud, whereas an average of 35 percent of the plants in four replications without treatment showed bud symptoms. In streptomycin-treated plots the average disease index was 4.0 as compared to 41.7 in plots without treatment (Table 4). The disease index of 4.0 resulted from infection of older leaves prior to any chemical treatment and was not due to new infections. Only 5 percent of the leaves examined from the untreated areas did not show wildfire; whereas 79 percent of all leaves examined from plots receiving three applications of streptomycin were not infected.

Severe outbreaks of wildfire appeared in many farmers' plant beds, and since the results with the antibiotic were so favorable in critical tests, streptomycin was given to five different growers who applied two or more treatments at the 200 p.p.m. rate to 30 square yards or more of plant bed, leaving the remainder of each 100 square yard plant bed without treatment. Similar striking wildfire control after disease appearance were observed in each of these grower plant beds.

Effects of Streptomycin on Growth of Plants in Absence of Wildfire

In one series of treatments streptomycin sulfate was sprayed at rates of 120, 240, 480, and 960 p.p.m., on potted plants with leaves 2 to 3 inches in length at the beginning of treatments. Also included in the series were the insoluble salt of streptomycin, at rates of 120 p.p.m. sprayed, and 300 p.p.m. dusted; Tri-basic-copper sulfate at the recommended rate; and no chemical treatment. Three applications were made at weekly intervals to three plants for each treatment. Both upper and lower surfaces of the leaves were thoroughly wet with the sprays. At the highest rate, 960 p.p.m., slight chlorosis of leaves developed following one application. Two applications resulted in conspicuous chlorsis at both the 480 and 960 p.p.m. rates. By one week after third application spotty chlorosis developed also with 240 p.p.m. but not with 120 p.p.m. By this time, however, all plants in the test were somewhat nitrogen-defieient, which made observation difficult. An application of nitrate of soda resulted in normal new growth in all treatments, giving evidence that the plant injury observed with highest rates of antibiotic was only temporary in nature.

Observations were also made on the effects of streptomycin in the absence of wildfire on plants grown in a plant bed. Four 2 1/2 square yard plots were treated with five weekly applications of streptomycin at 120 p.p.m.. Comparable plots were treated with Tri-basic-copper sulfate and others were left without treatment. All plants grew satisfactorily and no conspicuous difference in growth between plots could be seen. Slight wildfire, and also blue mold (Peronospora tabacina), developed in some of the treated plots by May 18, two weeks after last application. Wildfire was no doubt introduced as a result of pulling plants for transplanting in the experimental bed. This indicates that protection may not last for more than two weeks after sprays are discontinued.

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CONTROL OF PEAR BLIGHT BY A STREPTOMYCIN-TERRAMYCIN MIXTURE[1]

John C. Dunegan, Jess R. Kienholz, R. A. Wilson, and W. T. Morris[2]

Pear blight control has long been a major problem of the pear industry in the Pacific Coast States. The causal organism, Erwinia amylovora, has been held in check by a costly program involving the removal of all infected parts, supplemented in some cases by spraying or dusting the trees with copper compounds. Not infrequently the fruit is badly russetted by these copper preparations. Sulfur and several dithiocarbamates have been tested as substitutes but they do not offer a complete solution to the problem. There is an urgent need for efficient but less phytotoxic materials.

During the past two years streptomycin and Terramycin[3] have been tested in various parts of the country to determine whether these antibiotic materials will control pear blight.

Exploratory tests in 1952 at Plant Industry Station, Beltsville, Maryland, showed that streptomycin was relatively non-phytotoxic to pear leaves and our small-scale field experiments in 1953 in California and Oregon demonstrated that streptomycin applied as a spray at 100 p.p.m. reduced the incidence of blight, did not russet the fruit and caused only a mild chlorosis on some leaves.

Goodman (2), Heuberger and Poulos (3), and Winter and Young (5) have already published accounts of their experiments with antibiotic materials for the control of pear blight on apple trees east of the Rocky Mountains and Ark (1) has reported similar experiments on pear trees in California. The present paper discusses the results of a large-scale experiment in California in 1954.

The 1954 Experiment

In 1954, a 20-treatment experiment, involving 600 bearing Bartlett pear trees, was set up at Marysville, California[4], to determine the commercial feasibility of using antibiotic materials for pear blight control.

In this experiment the effectiveness of three antibiotic concentrations, applied either 3 or 4 times at intervals of 14 days or 5 or 7 times at intervals of 7 days, was compared with tribasic copper sulfate applied 5 or 7 times at intervals of 7 days. Other treatments included a mixture of the antibiotic material and zineb[5] and a series of check plots sprayed with water. Each treatment was applied to 30 trees divided into 6 randomized groups of 5 trees each.

Spraying operations started on March 29, when approximately 20 percent of the blossoms were open. As shown in Table 1, treatments involving 3 and 5 applications were completed on April 26, while those involving 4 and 7 applications continued until May 10.

All the trees were sprayed from the ground using a 4-nozzle type broom at 600 p.s.i. pump pressure.

Results

All blight infections that could be seen were cut out of the trees on May 20 and 21. A final cutting was made on June 9 at the end of the period of rapid spread of the organism. The number of infections from these two cuttings was taken as the measure of effectiveness of the various treatments.

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[1] Agri-mycin 100, a trademarked formulation furnished through the courtesy of the Chas. Pfizer Co. Inc., Brooklyn, N.Y., contains 15 percent streptomycin, 1 1/2 percent Terramycin, a wetting agent, an acidifying agent and an inert carrier.

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[3] (R) Brand of oxytetracycline, Chas. Pfizer Co. Inc.

[4] We are indebted to the DiGiorgio Fruit Corporation for the use of these trees, spray machinery and other facilities.

[5] Rohm and Haas Co., Philadelphia, Pennsylvania, kindly supplied Dithane Z-78, its brand of zineb, for this work.

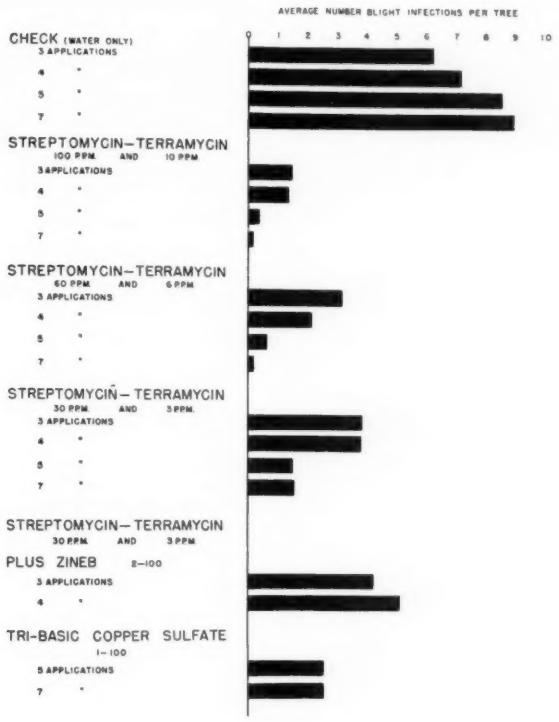

FIGURE 1. Average number of blight infections per tree on Bartlett pear receiving various spray treatments, Marysville, California, 1954.

These data and a summary of the statistical analysis[6] are given in Table 2 and the average number of infections per tree is shown in Figure 1.

The data in Table 2 and Figure 1, which relate only to the conditions prevailing at Marysville, California, in 1954, can be interpreted as follows:

(1) All the antibiotic treatments were significantly better at the 1 percent level than the check plots receiving a comparable number of applications of water.
(2) The number of blight infections increased in the check plots as the number of applications of water increased.
(3) In general the number of blight infections decreased as the concentration and number of antibiotic sprays increased.
(4) There is no significant difference between the treatments receiving 3 applications of the streptomycin-Terramycin mixture at 100-10 p.p.m. and those receiving 5 applications at 30-3 p.p.m.
(5) The additional sprays applied after April 26 at intervals of either 7 or 14 days did not give a significant increase in blight control.

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[6] E. J. Koch of Biometrical Services, Agricultural Research Service, aided in designing the experiment and made the statistical analysis of the data.

Table 1. Schedule of spray applications to Bartlett pear trees, Marysville, California, 1954

Number of sprays	Interval between sprays	Dates sprays were applied
3	14	March 29, April 12, 26
4	14	March 29, April 12, 26, May 10
5	7	March 29, April 5, 12, 19, 26
7	7	March 29, April 5, 12, 19, 26, May 3, 10

Table 2. Blight infections on Bartlett pear trees receiving various spray treatments, Marysville, California, 1954.

Treatment and concentration	Number of applications	Blight infections per treatment	
		Total number	Treatment mean number
Check (water only)	3	187	31.16
"	4	216	36.0
"	5	257	42.83
"	7	268	44.66
Streptomycin (100 p.p.m.) and Terramycin (10 p.p.m.)	3	44	7.33
"	4	41	6.83
"	5	11	1.85
"	7	5	0.85
Streptomycin (60 p.p.m.) and Terramycin (6 p.p.m.)	3	95	15.87
"	4	64	10.67
"	5	20	3.33
"	7	6	1.00
Streptomycin (30 p.p.m.) and Terramycin (3 p.p.m.)	3	116	19.33
"	4	115	19.17
"	5	45	7.50
"	7	46	7.67
Streptomycin (30 p.p.m.) and Terramycin (3 p.p.m.) plus zineb (2 lbs. in 100 gals.)	3	127	21.16
"	4	154	25.66
Tri-basic copper sulfate (1 lb. in 100 gals.)	5	76	12.66
"	7	76	12.66
L.S.D. 5%			5.44
L.S.D. 1%			7.25

(6) When the two time intervals (i.e. 7 and 14 days) were compared a significantly higher blight infection was noted at the 14-day interval, except at the 100-10 p.p.m. concentration. This indicates that, at the lower concentrations, 14 days was too long an interval between sprays for efficient blight control. In a previous report on the control of this disease in California Scott (4) stated that during periods favorable to the development of blight, copper sprays should be applied at intervals of 5 or 6 days.
(7) The addition of zineb to the antibiotic spray did not enhance the control of blight.
(8) The blight control obtained with 5 or 7 applications of the minimum antibiotic concentration (30-3 p.p.m.) was as good as the results obtained with the tri-basic copper sulfate spray. The higher concentrations (100-10 and 60-6 p.p.m.) were significantly better.

Field observations during the course of the experiment showed that typical copper injury appeared on the leaves as early as April 5 (after only one application). As the season progressed typical copper russet developed on the fruit and at harvest all the copper-treated plots could readily be distinguished from the other plots because of the roughened, dull appearance of the fruit.

In contrast, the antibiotic treatments caused no injury to the fruit, but did produce chlorotic patterns on the leaves that unfolded early in the season. This leaf reaction was most pronounced in the 100-10 p.p.m. treatments and was present in the 60-6 p.p.m. treatments, but in the 30-3 p.p.m. treatments only an occasional leaf developed chlorotic symptoms.

Discussion

The results of this experiment indicate the streptomycin-Terramycin mixture applied as a spray was highly effective in pear blight control without causing the severe russet that often results from the use of copper sprays or dusts.

Comparable results were obtained when a streptomycin liquid concentrate[7] was applied with a speed sprayer to 6 non-randomized, non-replicated blocks of 20 trees each. In this semi-commercial test, adjacent to the main experiment, control of the disease increased with an increase in the antibiotic concentration of the sprays but did not change when the number of applications was increased from 5 to 8.

The results of these two tests indicate the effectiveness of the antibiotic materials for pear blight control. The commercial feasibility of their use will depend upon their cost in relation to the amount of injury to the fruit that results from present control practices. In this connection the results obtained with 5 applications of the streptomycin-Terramycin mixture at 30-3 p.p.m. are of particular interest. This is the lowest concentration used that gave blight control comparable with that obtained with the copper spray. It caused no injury to the fruit and only a trace of leaf chlorosis.

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[7] Agri-mycin 200, Chas. Pfizer Co., Brooklyn, N.Y. A liquid concentrate containing 35 percent streptomycin.

DISTRIBUTION OF SCLEROTINIA CAMELLIAE IN NORTH CAROLINA, 1950-1954

N. N. Winstead, E. C. Nelson, Jr., and Frank A. Haasis[1]

Flower blight of camellias incited by Sclerotinia camelliae Hara (1, 2) was first discovered in North Carolina by Watson (3) as a result of culturing tissue plantings from a few diseased flowers (Camellia japonica L.) collected in Brunswick County on March 16, 1950. Coincident with this discovery an immediate search was made for apothecia in the area from which the diseased flowers were collected; however, none was found until the spring of 1951.

As a result of this initial report and its confirmation one year later, a survey was begun in 1951 and continued through 1954 in order to determine the distribution of the disease in North Carolina. During most of this period, the inspections were made chiefly at nursery establishments located in 22 counties of the State (Fig. 1). Periodic inspections of a few public and private gardens were also made each season but no deliberate search was initiated in such plantings until the spring of 1954. Through this effort the causal agent of flower blight of camellias has been found on 18 properties in four counties in North Carolina (Fig. 1).

In 1953 apothecia and sclerotia of S. camelliae were found in a nursery in Wilson County, a distance approximately 140 miles from the initial site of infestation in Brunswick County. Presence of the disease in other sites went undetected until 1954, when it was found prevalent in the Camp Lejeune area of Onslow County, in 13 private gardens and one nursery in New Hanover County, and in one additional garden in Brunswick County.

The period of inspection ranged from November 6 to April 9 in order to include the normal blooming season for camellias in the Piedmont and Coastal regions of North Carolina. The earliest recorded date for the appearance of apothecia of S. camelliae for southeastern North Carolina was January 26 and the latest was April 5; the apothecia have been most numerous, however, during the months of February and March.

Throughout the course of this survey all disease diagnoses were confirmed one or more times from each location by culturing the organism either from apothecia or diseased flowers or both, depending on availability. In Wilson County in 1953 identification was based on apothecial and sclerotial morphology, which corresponded well with the characteristics considered typical for S. camelliae. Revisits to the Wilson County site during the 1954 season failed to yield additonal fruiting bodies of the fungus and at no time have diseased flowers been present.

On the basis of numbers and distribution of apothecia in most of the infested properties, it is concluded that the flower blight organism was introduced at least one and possibly two or more seasons prior to discovery in any given location. This generalization may not pertain to the site in Wilson County nor to two or possibly three private gardens in the residential area of Wilmington. There is some evidence to support the belief that S. camelliae was introduced into the nursery in Wilson County through the transport and deposition in 1952 of diseased blossoms acquired elsewhere. Infections in the two or possibly three properties in Wilmington could have arisen from wind-borne ascospores released from mature apothecia produced on adjacent properties. Failure to find apothecia at a particular inspection, however, does not necessarily mean they are non-existent, for they can be easily overlooked particularly when sparse. Hence, in a few instances positive disease diagnosis was based solely on isolation of the pathogen from diseased flowers, since no apothecia were observed. Failure to isolate S. camelliae from diseased blossoms in many instances may be due to its suppression by secondary invaders such as Pestalotia, Alternaria, Penicillium, and numerous saprophytic yeasts and bacteria. To conclude, therefore, that any camellia planting is free from the flower blight disease on the basis of a single inspection or culturing from flower material made at one collection would appear unwarrented.

There is reasonable likelihood that the actual distribution of S. camelliae in North Carolina exceeds the present known proven range of the pathogen. This conclusion applies particularly to home plantings in residential areas such as Wilmington where camellias are used extensively in landscaping. Hence, dissemination of the pathogen may be expected from wind-borne and rain-borne inoculum. Furthermore, infested areas may be anticipated in counties outside the three bordering the sea coast, as the one instance of infestation in the inland county of Wilson

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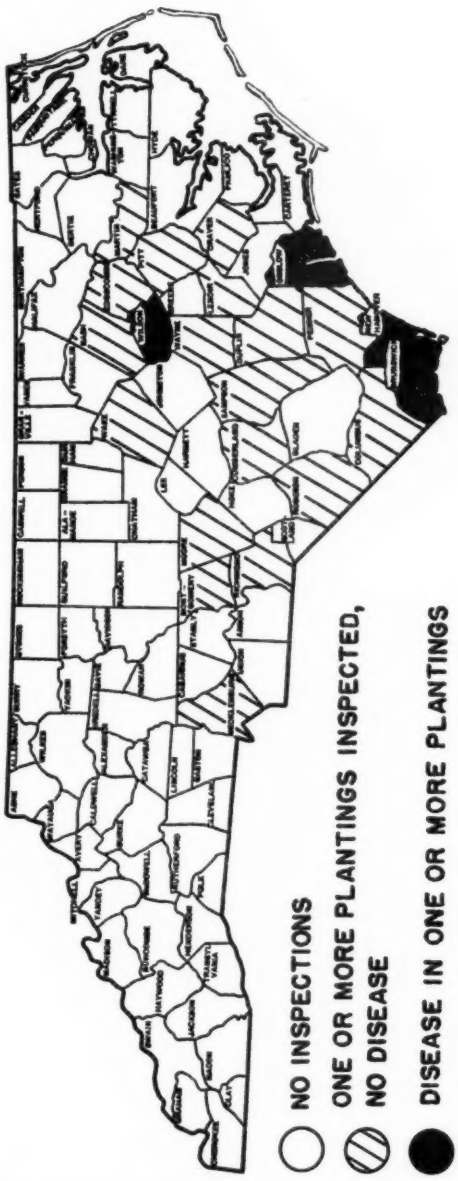

FIGURE 1. DISTRIBUTION OF SCLEROTINIA CAMELLIAE IN NORTH CAROLINA, 1950-1954.

will attest.

There is reason to believe that camellia plants have been distributed from infested to non-infested areas in North Carolina, as well as from infested areas outside the State. This movement of plants occurred prior to any knowledge of such infestation and hence without taking steps to prevent the movement of the pathogen with camellia plants. The validity of this conclusion must await additional survey work supported by confirmational evidence through laboratory assay.

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AN OUTBREAK OF CAMELLIA FLOWER BLIGHT IN GEORGIA[1]

D. L. Gill[2] and John Ridley[3]

In the late afternoon of February 20, 1954, some camellia flowers with typical early symptoms of camellia flower blight caused by Sclerotinia camelliae Hara were observed in a Georgia camellia flower show. These flowers when presumably in good condition had been entered in the show in the morning. Platings from this material yielded Sclerotinia camelliae. The two private gardens in Augusta, Georgia, from which the suspected flowers had come were visited on February 23. Infected flowers, sclerotia, and apothecia were found in abundance.

Subsequent inspections during the remainder of the flowering season revealed the disease in 17 private gardens in the city. These properties were in an area approximately one-fourth of a mile square. No other infections were found, although numerous inspections were made in other locations in and around the city. The infested areas were quarantined by the Georgia Department of Entomology. The old flowers and mulches were destroyed and chemical soil treatments were initiated immediately upon location of the disease on a property.

From the distribution of the disease on the properties, it is believed that it has been present several years. Even though symptoms were readily observed in late February and early March, the disease had not previously attracted the attention of the home owners. Plants have been brought into these gardens from all over the camellia area. No information as to where the disease came from could be obtained.

Camellia flower blight was previously reported by Gill[4] in greenhouses and in the open on one private property in Georgia.

GEORGIA COASTAL PLAIN EXPERIMENT STATION; AGRICULTURAL RESEARCH SERVICE, U. S. DEPARTMENT OF AGRICULTURE; AND GEORGIA DEPARTMENT OF ENTOMOLOGY

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[1] Contribution of the Department of Plant Pathology, Georgia Coastal Plain Experiment Station. Published with the approval of the Resident Director, Journal Series Article #25.

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[3] Inspector, Georgia Department of Entomology.

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THE STATUS OF LEPTOSPHAERIA HETEROSPORA ON IRIS RHIZOMES

Paul R. Frink

During the importing season of 1951-52 considerable numbers of iris rhizome shipments were entered through the San Francisco Plant Quarantine Inspection Station from foreign countries. These rhizomes were observed in a variety of conditions depending on the packing material used and the length of time the plants had been dormant or in storage prior to shipping. Low-power microscopic examination of certain imported lots revealed the presence of black, scattered fungus fruiting bodies, particularly on the older portions of the divided or cut rhizomes. In many instances, the areas in which these fruiting bodies were located were shriveled and decayed. In nearly all cases the fungus present was Leptosphaeria heterospora. This led to the speculation that the organism might be a parasite of undetermined potentialities.

This fungus has been reported in a few Eastern States, both as a parasite and a saprophyte. In 1939, a British publication, "Diseases of Bulbs, Bulletin No. 117" of the Ministry of Agriculture and Fisheries, by W. C. Moore, commented on Leptosphaeria as follows: "In 1928 Drayton referred to a root rot that had been prevalent at Ottawa the previous year. After making good growth for several weeks the leaves turned yellow, brown and dry and on lifting the plants the roots were found to be dead and reduced to dry, hollow tubes. The rhizomes were not decayed but perithecia of Leptosphaeria heterospora (de Not.) Niessl, and pycnidia of a species of Phoma, were constantly present in large numbers on the upper, and especially on the under surfaces of the rhizomes as well as on the roots. L. heterospora had previously been recorded on iris rhizomes in Europe (Sacc. Syll. Fung. 2, 67) and it was found again on the rhizomes and roots of Iris germanica in Surrey and near London in 1930 (479, p. 111) and on Oncocyclus rhizomes imported from Persia in 1931. The following year it was seen in association with pycnidia of a Septoria on the rhizome and roots of an I. pumila formosa plant grown in Kent. No attempt has been made to determine whether the Leptosphaeria is a parasite."

The disease potentialities of this organism prompted a request by the State of California that the Division of Plant Quarantines reject all infected shipments of rhizomatous iris from foreign countries that were destined for that State, since the fungus had not at the time been reported west of the Mississippi River. As a means of determining whether or not visibly clean rhizomes in shipments with infected rhizomes might be treated and grown free of the disease, an arrangement was made with the Division of Plant Introduction and Exploration to cooperatively use their facilities for quarantine growing at Chico, California. Two hundred thirty-nine iris rhizomes imported from England, Holland, and Trans-Jordan, comprising nine different species, were planted on November 17, 1951. They were grown under quarantine safeguards to determine whether the fungus, Leptosphaeria heterospora, might persist and cause damage to these rhizomes, even though they were selected as visibly free of disease symptoms at the time of importation. Since they were taken from lots in which the disease had been found, they were dipped for 30 minutes in 1% Semesan solution before planting to eliminate surface contamination.

On July 10, 1952, at the suggestion of the owner of the plants, all rhizomes were dug up and examined for presence of damage, disease, or fungus fruiting structures of Leptosphaeria heterospora. The plants had been dormant for some time. Those present, in addition to the owner of the iris and the writer, were Mr. George E. Altstatt of the California Bureau of Plant Pathology and Mr. Lloyd Joley, Superintendent of the Plant Introduction Garden. Considering the delay in planting and the treatment given, a remarkably high number of rhizomes matured normally. With the exception of four rhizomes of Iris susiana, all were accounted for.

In general, the results were as follows: All species of iris showed some infection by L. heterospora. The over-all percentage of the rhizomes infected was 33.2 percent. No infection was found on the current season's portion of the rhizomes, but it did occur on the older ends of the rhizomes planted the previous fall. It was evident that this fungus was not eliminated by the Semesan surface treatment. The organism appeared to be able to penetrate the rhizomes and maintain itself without damaging the tissues. An abundance of fruiting bodies were found in the old rhizomes containing many four-celled Leptosphaeria spores.

Under conditions at Chico, the fungus does not appear to be more than a saprophyte. That it is a saprophyte under all conditions has not been determined, and more work needs to be done under controlled moisture and temperature conditions. There is also an unconfirmed possibility that this fungus is an omnipresent soil-borne organism. The condition of the importations as they arrived from foreign countries suggested that the fungus might be causing some damage,

especially to the more slender stoloniferous type of rhizomes. No repetition of such damage was evident in any of those examined at Chico. This suggested that in the absence of soil moisture and nourishment the fungus slowly consumes portions of the rhizome to sustain itself. Otherwise, under normal and optimum iris-growing conditions, it appears to be no more than a saprophyte.

At the present time the records of the San Francisco office of the Plant Quarantine Branch show the occurrence of the fungus, Leptosphaeria heterospora (de Not.) Saccardo, on rhizomes of many species of iris from ten different countries: Australia, Canada, England, France, Holland, Israel, New Zealand, Trans-Jordan, Turkey, and the United States. An article appeared in "Mycologia" May-June 1952, p. 330, under the title "Cultural Studies of the Genera Pleospora, Clathrospora and Leptosphaeria" by Emery G. Simmons. Leptosphaeria heterospora was one of the fungi studied and it was of interest to note that it was taken from Trisetum spicatum and Poa epilis, both native grasses at Mt. Shasta, California in 1947. During 1952, the fungus was also taken from small home garden iris plantings at San Lorenzo, California. Material from four such gardens was collected and was found to be infected with Leptosphaeria. Specimens were submitted to specialists of the Division of Mycology and Disease Survey who confirmed the organism as L. heterospora (San Francisco interception No. 29381). This material is filed in the National Fungus Collections, Horticultural Crops Research Branch (formerly Mycological Collections of the Bureau of Plant Industry, Soils and Agricultural Engineering). Through the medium of the San Lorenzo Garden Club, many surplus iris rhizomes have been exchanged among the members. On August 8, 1952 the California Bureau of Plant Pathology inspected nine lots of iris near Placerville, California. All lots were found infected. These observations suggest the fungus may occur at more than one locality in Central and Northern California on both native and introduced plants, and that it is probably of little or no consequence as a parasite.

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MAT FORMATION BY THE OAK WILT FUNGUS ON FELLED VERSUS STANDING TREES

John S. Boyce, Jr.

Observations which have a bearing on control efforts, have been made on the time of mat formation by the oak wilt fungus, Endoconidiophora fagacearum, in connection with the available information on time of infection. Limited observations in North Carolina and Tennessee showed that wilting trees which were felled and bucked into logs during the summer and early fall produced mats only during the same fall. Some infected trees that were left standing, however, produced mats the spring following the appearance of wilt symptoms.

Available information indicates that oaks may be naturally infected mostly in the spring. Jeffery (4) cited cases of spring infections in Pennsylvania. Oaks that were blazed along a logging trail in April 1952 developed wilt. Scattered trees that were trimmed along a power line in May 1953 became infected. He noted that oaks wounded as a result of logging during the period of springwood formation in 1953 became infected, whereas other oaks on the same area that were wounded at other times of the year remained wilt-free. No wilt developed among 165 oaks that were pruned along a utility line in August 1953.

An experiment in which oaks were wounded periodically from March 23 to July 31, 1953, in Pennsylvania (2) supplements Jeffery's observations. Eight of a total of 194 trees became infected. The infected trees were wounded from May 11 to June 2, and the wounds were exposed to natural infections for about one week before they were covered.

If it is established that natural oak wilt infections occur mostly in the spring and early sum-summer, then adopting a summer felling schedule to cause autumn mat formation would simplify control. The following data show that for southern Appalachian conditions, summer cutting of wilting trees resulted in fall fruiting only, whereas more than half of the wilting trees left standing produced mats the following spring.

A total of 52 wilting trees, 4 to 25 inches in d.b.h., were felled and bucked into 6- to 10-foot logs. Twenty-three trees were felled during the summer of 1952, and 29 trees during the summer of 1953. The trees were examined for fruiting mats periodically until June of the year following cutting.

Mats of the wilt fungus appeared on the logs of six trees. They formed only in the fall of the two years concerned (Table 1).

Table 1. Mat formation by the oak wilt fungus on standing and felled trees.

Cut or left standing and year of wilting		Observed	With mats formed same fall[a]	With mats formed following spring[b]
Felled trees[c],	1952	23	1	0
	1953	29	5	0
	Both years	52	6	0
Standing trees,	1953	22	0	12

[a] September to November.

[b] March to May.

[c] Trees felled between July 2 and September 9, 1952, and June 30 and September 29, 1953.

Twenty-two trees observed to be wilting in the summer of 1953 were left standing. Twelve of them bore exposed fresh mats in the spring of 1954 (Table 1). Workers elsewhere have found mats of the wilt fungus on standing trees in many months of the year (1, 3, 5).

Thus, trees that were cut and bucked in the summer produced mats the same fall, a time when oak wilt infection may be relatively unlikely. We plan to fell and buck more infected trees to observe the time of mat formation on them. Workers elsewhere may wish to do the same,

inasmuch as time of mat formation on cut trees may not be the same in other localities. Such data, together with more complete information on the main time of natural infection, may indicate whether summer felling alone, without disposing of the tree or treating it chemically, will be a feasible method of avoiding overland spread of oak wilt. We have observed heavy insect invasion of mats formed in the fall. However, this may be a matter of little importance if oaks prove to be rarely infected in fall or winter. In the current studies all mats formed in the summer or fall were disintegrated by the following spring, which, by present indications, may be the principal season of natural infection.

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SOUTHEASTERN FOREST EXPERIMENT STATION, FOREST SERVICE, UNITED STATES DEPARTMENT OF AGRICULTURE, ASHEVILLE, NORTH CAROLINA

AN EPIPHYTOTIC OF PHYLLOSTICTA LEAF SPOT OF MAPLE

Charles L. Fergus

The purple-bordered leaf spot of red maple, sometimes called eyespot, caused by Phyllosticta minima (Berk. & Curt.) Ell. & Ev., has been extremely severe this spring in northwestern Pennsylvania. Observations made in mid-June by Professor R. A. Bartoo, of the School of Forestry, in and around Marienville, Forest County, Pennsylvania, and in the Allegheny National Forest, showed that approximately 50 percent of the red maples (Acer rubrum L.) and a smaller percentage of the hard maples (Acer saccharum Marsh.) were infected.

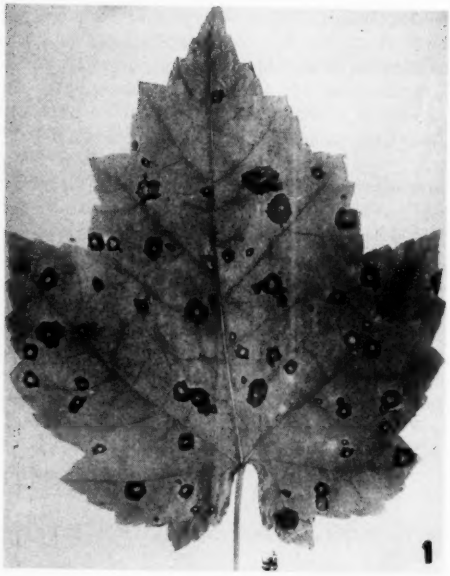
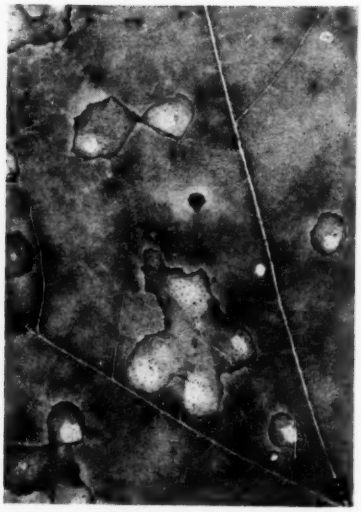


FIGURE 1. Leaf of Acer rubrum showing the small circular necrotic spots caused by Phyllosticta minima.

FIGURE 2. Leaf of Acer saccharum illustrating the necrotic spots caused by Phyllosticta minima.

FIGURE 3. A closeup of Figure 2 to illustrate the large irregular type of necrotic spot. The small black dots are the pycnidia.



The symptoms and signs exhibited by the affected leaves of red maple varied from the description given by Seaver (2) and therefore they will be described here. The large majority

of spots were not single, indicating coalescence of several spots so that a large irregular necrotic area resulted. In some cases, this area involved one-half of the leaf. The individual spots were irregularly circular, at first entirely dark brown, then with a paler center and dark margin, often reddish-brown or purple-brown (Fig. 1). Large numbers of black pycnidia were observed, often distributed in a circle, 75-150 (occasionally up to 225) microns diameter. The spores were ovoid to globose, smooth, hyaline, 7.5-9 (11) x 4 - 7.5 microns.

A considerable amount of defoliation of the diseased leaves had occurred by early June.

The disease was also observed on hard maple (Fig. 2 and 3), but the severity was less than on red maple. A check of the University Herbarium showed that of 47 different Pennsylvania collections, 36 were on A. rubrum, 6 on A. saccharum, and 2 on A. saccharinum.

Seaver (2) lists Phyllosticta saccharina Ell. & G. Martin as occurring on A. saccharum, but not P. minima. Weiss (3) indicates the probability that these two species of fungi are synonymous. A careful examination of a large number of these collections, on hard and red maple, showed that although the microscopic characters were constant, there is a variation in the spots on the different species of maple that appears to be without taxonomic significance. Sometimes all the spots on a leaf are individual and only 3-4 mm. diameter and dark in color with a central somewhat lighter area about 1-2 mm. diameter (Fig. 1 and 2). At other times, larger, less regular, spots predominated (Fig. 3). Species age and environment may cause these variations in the disease symptoms, hence making them of practically no taxonomic value. The effect of environment on leaf symptom expression has been demonstrated by various workers, including Beach (1), who found that the spots on Lactuca canadensis L. caused by Septoria lactucicola Ell. & G Martin lost their concentric zones and became spreading when kept for a long time in a moist atmosphere. It is interesting to note that rainfall for Forest County in the spring of 1954 was considerably above normal.

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A MODIFICATION OF THORNE'S TECHNIQUE FOR EXAMINING SOIL DIFFUSION PATTERNS OF NEMATOCIDES[1]

Harold J. Jensen, Fields E. Caveness, and Roland H. Mulvey[2]

Summary

Soil diffusion patterns or "K-values" of ten nematocides were obtained by examination of field soil profiles. The field profile samples were taken to the greenhouse and seeded to hairy vetch, an indicator plant for Pratylenchus penetrans, the test animal of this investigation. The nematodes were removed from the roots and counted in the usual manner.

The technique described was used to process the diffusion patterns of "spot-" and "bar-type-" injections for each material. Diffusion patterns of bar-injections usually failed to show corresponding increases in size over those obtained from spot-injections when the same amounts of material were used. Most materials failed to control the nematodes below the plow sole or in the upper 2-inch soil zone since the nematodes were usually recovered from those areas.

While these soil profile-diffusion tests are not intended to rate the nematocidal efficiency of various materials, such field data from the site of an actual nematode problem are probably reliable in prognosticating field results.

Introduction

Soil fumigation as a method of control for soil-borne plant parasitic nematodes and other plant disease organisms has recently received a great deal of attention in this country and elsewhere. Numerous investigators have attempted to evaluate the field control efficiency of various soil nematocides by laboratory and greenhouse methods. While these methods have their place in the early stages of any program for evaluating nematocides, correlations between data obtained in such trials and those obtained in field control operations are often disappointing. The artificial climatic and edaphic conditions established in the laboratory or greenhouse are not truly representative of field conditions. Thus the Petri dish tests of the laboratory, open or closed container tests, or a procedure of burying nematodes at various distances from the point of injection and similar greenhouse technique are often unreliable guides for predicting the value of nematocides in cultivated fields.

Although unsatisfactory results are frequently obtained, practical field control of soil-borne plant parasitic nematodes by the application of nematocides to the soil is constantly being achieved. Poor results in the field are due largely to improper preparation of the soil, untimely applications with respect to unfavorable soil temperature or moisture conditions, and the failure to use the amount of material required for control.

The influence of various field conditions upon the diffusion patterns or "K-values" (1) of nematocides should also be considered if best results are to be achieved. The described technique was used to make a preliminary study of the soil diffusion patterns of the following ten materials against a specific nematode pest under field conditions:

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[1] Approved for publication as Technical Paper No. 862 by the Director of the Oregon Agricultural Experiment Station. Contribution of the Department of Botany & Plant Pathology.

[2] Assistant Nematologist, Graduate Research Assistant, and Graduate Student, respectively, Oregon Agricultural Experiment Station. The authors are indebted to Gerald Thorne (Senior Nematologist, Nematology Section, USDA) for his suggestions, and to H. H. Millsap (Research Assistant, Coop. USDA, Oregon Agricultural Experiment Station) for the photographic preparation of the charts used in the article.

Material Tested	Composition	Manufacturer	Diffusion Patterns Obtained
AC-14 CBP-55	(not disclosed)	B. F. Goodrich Chemical Co.	Fig. 1A & B
CBP-55	Chloro-bromopropene	Shell Chemical Corporation	Fig. 1C & D
DD	Dichloropropene-dichloropropane	Shell Chemical Corporation	Fig. 1E & F
EDB	Ethylene-dibromide (W-85)	Dow Chemical Company	Fig. 2A & B
EDB + PN	(mixture of 50% EDB W-85) + (50% not disclosed)	Dow Chemical Company Phillips Petroleum Co.	Fig. 2C & D
Larvacide	Trichloronitromethane	Larvacide Products, Inc.	Fig. 2E & F
N-339	(not disclosed)	Stauffer Chemical Co.	Fig. 3A & B
NP-1414	Ethylisothiocyanate	Pennsylvania Salt Mfg. Co.	Fig. 3C & D
NP-1093 + NP-1353	Dichlorobutyne + (not disclosed)	Pennsylvania Salt Mfg. Co. Pennsylvania Salt Mfg. Co.	Fig. 3E & F
PN	(not disclosed)	Phillips Petroleum Co.	Fig. 4A & B

The soil profile-diffusion tests used to determine the "K-values" in this investigation were patterned after those devised by Thorne (3) but differed as follows: (a) a plant parasitic nematode was used as the test animal instead of the free living and saprozoic forms which naturally occur in the soil, and (b) an indicator plant was used to recover nematodes from the soil instead of the gravity-screening technique. Raski, Allen, and McCallum (2) used a technique similar to that developed by Thorne to obtain soil profiles for their efficiency studies of plow and chisel applications of nematocides against the sugarbeet nematode. They also used an indicator plant to recover nematodes from the soil. A plant parasite, Pratylenchus penetrans (Cobb 1917) Sher & Allen 1953, was used as the test animal because: (a) this nematode is responsible for serious plant disease problems in Oregon, (b) recent investigations indicate that certain nematocides may be specific against some species of nematodes, and information against this pest is desired for future control work, and (c) the nematode is rather sluggish and would probably be unable to move any great distance from the nematocide injection point.

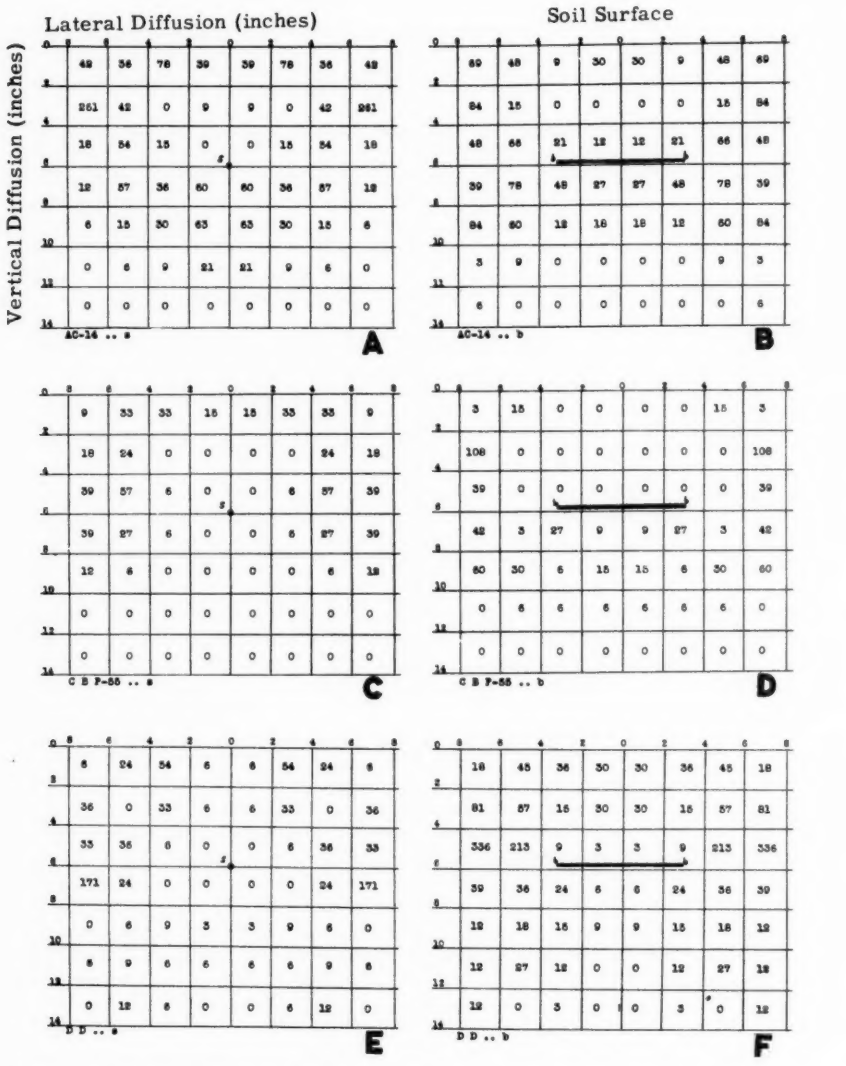
An indicator plant was favored over the gravity-screening technique of recovering nematodes from the soil for the following reasons: (a) to differentiate between living and dead nematodes, (b) to eliminate most of the free living and saprozoic forms from further examination, and (c) to stimulate the hatching of surviving eggs. Nematode eggs are usually not recovered from the soil by the conventional gravity-screening technique.

The following observation indicated that hairy vetch, Vicia villosa Roth., was effective in attracting P. penetrans from the soil. One-gallon cans containing infested soil were planted to vetch, and approximately 1500 root-lesion nematodes were recovered from each gram of root tissue some 60 days later. Examination of the water residue obtained from the soil remaining after the removal of the vetch plants revealed only an occasional root-lesion nematode.

Methods

The nematocides used during the investigation were applied to a site having a history of root-lesion nematode infestation. The population of this pest (several hundred per quart of soil) was sufficient to cause severe stunting of cherry seedlings. The surface soil was a Willamette loam overlying a silty clay loam sub-soil. The moisture content was 71.1 percent of the 22.56 moisture equivalent at the time of application. The plow sole was approximately 10 inches below the surface. Injections were made during the first week of September while the soil temperature was 69° F at the 6-inch application depth. A standard dosage of 1 cc. of formulation was used for all materials. A 10 ml. graduated pipette was used to apply the several materials

SOIL PROFILE DIFFUSION CHARTS



("s" material injected in a single spot; "b" material injected in a 6-inch trench)

FIGURE 1

(See text)

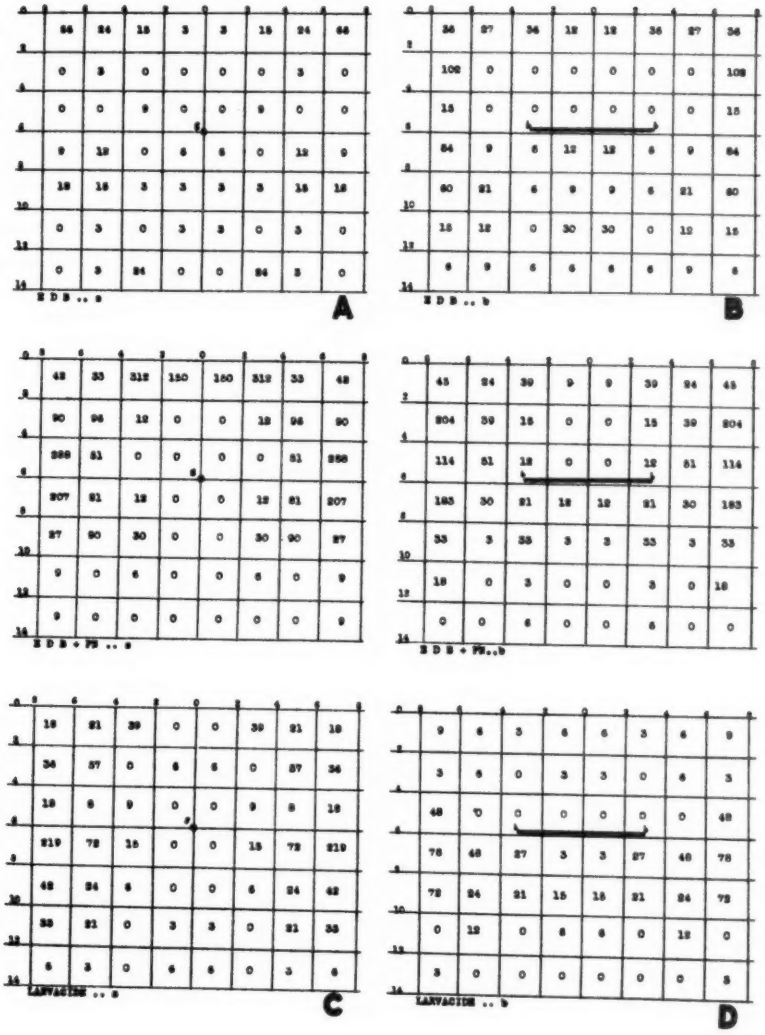


FIGURE 2

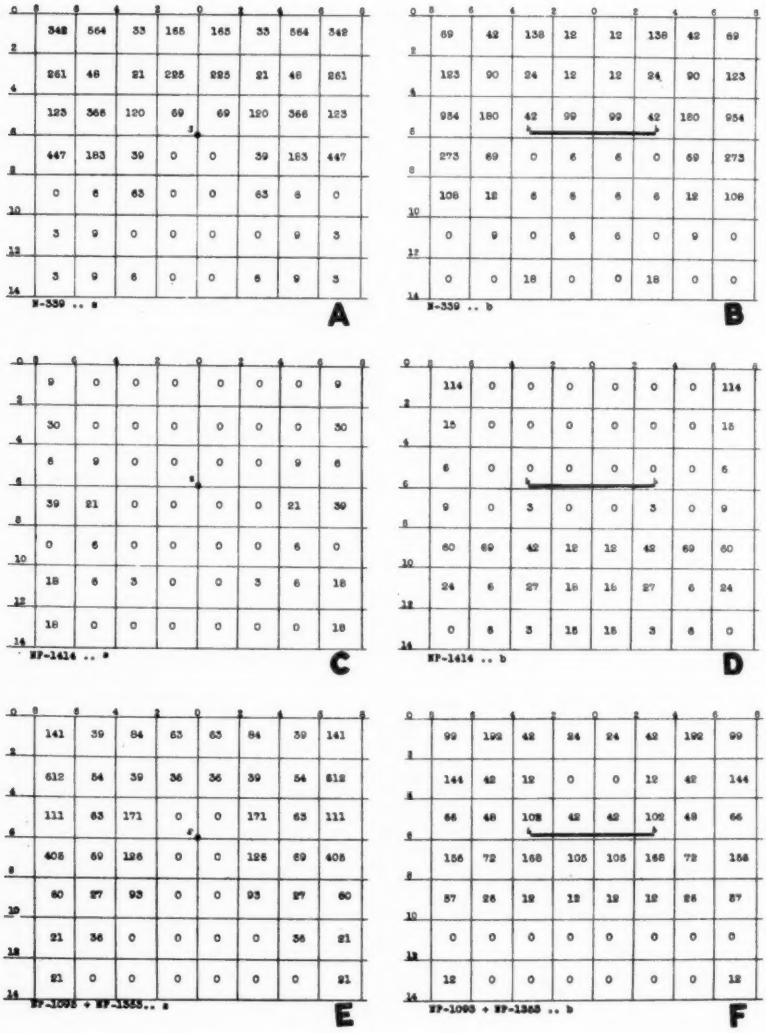


FIGURE 3

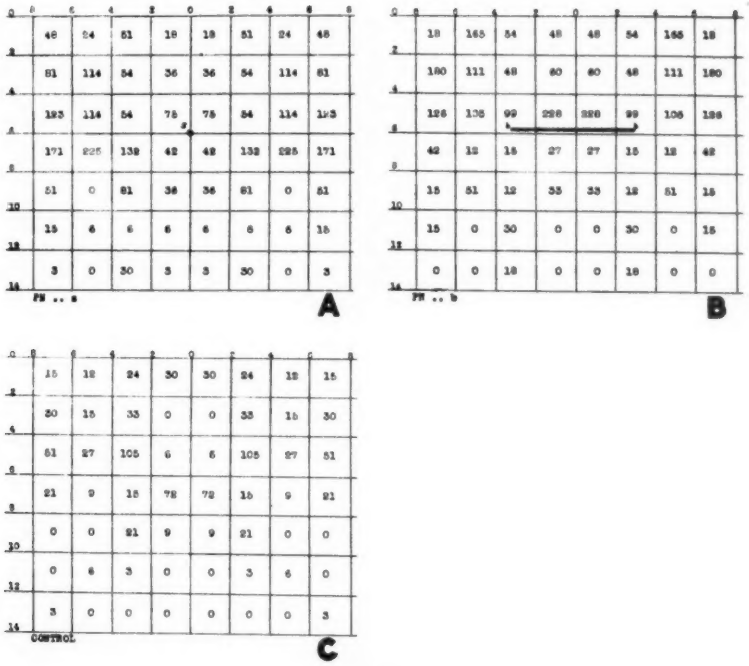


FIGURE 4

in spot and trench or bar type injections (Fig. 1-4, "s" & "b"). Although a water-seal was not used, the soil was lightly packed in a circular area of two feet surrounding the injection point immediately following application.

An Oakfield soil tube having a one inch daimeter was used to secure the soil samples in the following manner. A board (1 inch x 6 inches x 3 feet) drilled with 1 1/4-inch holes spaced at 2-inch centers from the central injection point served to orient the procurement of the samples. The center hole in the board was placed over the point of injection and eight 14-inch vertical columns of soil an inch in diameter were removed from four 2-inch intervals on each side of the injection point marker. A small metal scraper designed to fit the inside diameter of the soil tube served to cut the 14-inch columns into seven 2-inch sections and to remove any remaining residue after each section had been removed from the tube. A composite sample was made by combining samples from corresponding locations on each side of the injection location. Thus a total of 56 2-inch sections taken around each injection point was compounded into 28 samples. Each soil sample, weighing approximately 50 grams, was taken to a greenhouse and placed in a 2-inch pot containing enough additional nematode-free soil to fill the pot. Each pot was labelled with its corresponding field profile location and planted with five seeds of hairy vetch.

After three months the root systems were carefully separated from the soil and macerated in a Waring Blendor. The residue, liquid and solid (enclosed in a cheesecloth bag) was placed in a Baermann Funnel. A 60 cc. sample of water containing nematodes and some plant residue was withdrawn from the Baermann Funnel after a minmum 12-hour settling period. One-third of this sample (20 cc.) was examined for nematodes in the usual manner.

Discussion of Results

The data obtained from these tests are presented on schematic charts designed to simulate a soil profile and the diffusion patterns of the various materials tested. Two diffusion patterns

were obtained from each of ten materials to compare the efficiency of the "spot" and "bar" type injections. An additional untreated soil profile (Fig. 4C) completed the tests. The soil diffusion patterns of the various materials were not replicated because the amount of time required to process additional replication of the 588 indicator plants of the 21 individual soil profile examinations would have been too great, and the purpose of the tests was to modify a technique rather than to make an efficiency comparison of the nematocides used.

The number of nematodes recorded in the soil profile blocks is not particularly significant since all diffusion patterns could not be examined simultaneously and the nematodes in some samples had a longer time to build up greater populations. Therefore conclusions are based upon the presence or absence of nematodes in the profile blocks. Thorne (3) pointed out that the erratic distribution of the root parasites is largely dependent upon the distribution of the root system of their host plants. While the profile of the untreated soil (Fig. 4C) bore this out, there were usually some parasitic nematodes present in most areas of the upper 10 inches of soil. The population of root-lesion nematodes declined rapidly below the plow sole. However, the presence of some P. penetrans below the plow sole of the treated sites indicates that most of the materials are not effective in that area.

The diffusion patterns of most materials indicated that control was not usually achieved in the upper 2 inches of soil. The survival of nematodes in this area of the soil profile has also been reported by Thorne (3); Raski, Allen, and McCallum (2). However, two materials (Fig. 1D, Fig. 3C & D) apparently eliminated the nematodes from this difficult zone. The effective diffusion pattern of one material was increased by distributing the same amount of material used in a spot injection over the greater areas indicated in the bar injection (Fig. 1C & D). Other materials proved to be less effective when comparing the diffusion patterns of spot and bar type injections.

Data presented are not intended to be used as a general efficiency guide of the nematocidal activity of the materials tested. Such a comparison of one material with another in this investigation would be impossible for the following reasons:

a. A standard injection dosage of 1 cc. of formulation regardless of material concentration was used throughout the investigation. A fair comparison cannot be made because the various materials were formulated in different concentrations.

b. Several materials used in these tests are experimental, and dosages comparable with standard nematocides were not known.

c. Recent publications indicate that some materials may be specific against certain nematodes. A root-lesion nematode, Pratylenchus penetrans, was the only plant parasite used in this investigation.

d. The described conditions in which the investigation was conducted represented an actual nematode problem in Oregon. Some materials may be more effective in other areas having a different set of conditions.

The described technique of examining soil diffusion patterns of nematocides can be used to compare their control efficiency provided the injections are replicated and comparative dosages are used. Likewise the "K-values" of various materials against root-knot, cyst-forming, and other endoparasitic root-inhabiting nematodes can probably be determined in a similar manner.

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OBSERVATIONS ON PLANT-PARASITIC NEMATODES IN HAWAII

S. A. Sher[1]

During the period of July, 1952 to May, 1953 the following observations on plant parasitic and suspected plant parasitic nematodes were made in the Territory of Hawaii.

Nematodes marked with an asterisk are reported for the first time in Hawaii. Plants so marked are reported as a new host for these nematodes.

Permanent collections and slides have been made of all nematode material and are in the author's collection for future work and reference.

NEMATODE HOST	LOCALITY	OBSERVATIONS
APHELENCHOIDES BESSEYI		
Vanda x miss joaquim	Hawaii and Oahu	Cause of a serious disease in this important commercial flower.
Vanda x rose marie*	Hilo, Hawaii	Similar symptoms as in V. x miss joaquim.
Vanda x miss deun*	" "	"
Vanda x trimerrill*	" "	"
Vanda x puna*	" "	"
Vanda x miss joaquim x kapoho*	" "	"
strawberry	Maui	Numerous in buds of diseased plants.
hydrangea*	Hilo, Hawaii	Necrotic lesions on leaf delimited by veins.
dahlia*	" "	Necrotic leaves and flower heads.
chrysanthemum	" "	"
African violet*	Honolulu, Oahu	"
Shasta daisy	Hilo, Hawaii	"
marigold*	" "	"
zinnia*	" "	"
coleus	" "	"
tree marigold* (Tithonia diversifolia)	" "	"
Impatiens balsamina*	" "	"
Pluchea odorata*	" "	"
Erichtites hierafolia*	" "	"
Torenia fourniere*	" "	"
APHELENCHOIDES FRAGARIAE*		
strawberry	" "	Numerous in buds.
Polypodium phymatodes	" "	Necrotic lesions on leaf delineated by veins.
Nephrolepsis bisserata	" "	"
Vanda x miss joaquim*	" "	Often found in association with a sheath rot on stem; never found in terminal portion of plant, where A. besseyi is found.
Pentas lanceolata*	" "	In necrotic areas of leaves.
Impatiens balsamina*	" "	"
Ageratum conzoides*	" "	"

[1] Formerly Assistant Nematologist, University of Hawaii. Now Assistant Nematologist, Citrus Experiment Station, University of California.

NEMATODE HOST	LOCALITY	OBSERVATIONS
APHELENCHOIDES RITZEMA-BOSI		
chrysanthemum	Kulani Prison, Hawaii	In necrotic areas of leaves.
CRICONEMOIDES SPHAEROCEPHALUM[a]		
Sugar cane	Onomea and Hawi, Hawaii	Numerous in soil around sugar cane.
CRICONEMOIDES MUTABILE[a]		
Burdock* (Arctium lapa)	Maui	In lesions on roots.
HOPLOLAIMUS SP.		
Burdock* (Arctium lapa)	Kamuela, Hawaii	Numerous in root lesions and soil.
Lettuce	" "	In root lesions and soil.
Croton* (Codiaeum)	Hilo, Hawaii	Numerous around roots of dying croton.
Banana*	" "	Numerous around declining bananas.
DITYLENCHUS DESTRUCTOR[b]		
Iris	Olinda area, Maui	In bulbs and soil around declining iris.
DITYLENCHUS DIPSACI[b]		
Hypochaeris radicata	" " "	In leaf galls.
MELOIDOGYNE INCOGNITA VAR. ACRITA		
Tomato	Hanapepe, Kaui	
Dahlia	Honakaa, Hawaii	
Parsley	Hilo	
Impatiens balsamina	Hilo and Honokaa, Hawaii	
Papaya	Kapoa, Hawaii	
MELOIDOGYNE HAPLA		
Lettuce & Burdock	Kamuela, Hawaii	
PRATYLENCHUS BRACHYURUS		
Easter Lilly*	Hilo, Hawaii	Numerous in lesions on roots.
PRATYLENCHUS SP.		
Sugar cane	Hawi, Hawaii	"
RADOPHOLUS SIMILIS		
Anthurium andraeanum*	Hilo and Honomu, Hawaii	Numerous in root lesions and in soil; decline and dying of plants. Replants do not become established.
Bird of Paradise* (Steritzia)	Hilo, Hawaii	Numerous in root lesions and soil of declining plants.

[a] Identified by D. J. Raski, University of California.
[b] Tentative identification.

NEMATODE HOST	LOCALITY	OBSERVATIONS
RADOPHOLUS SP.		
Lotus* (Nelumbium nelumbo)	Oahu	Numerous in lesions on rhizomes of declining plants.
Banana	Hilo, Hawaii	Numerous in root lesions and soil.
TRICHODORUS SP.*		
Cabbage	Volcano area, Hawaii	Numerous in soil around stunted poor growing cabbage.
TYLENCHULUS SEMI-PENETRANS*		
Orange	Pahoa, Hawaii	Numerous on roots.
XIPHINEMA AMERICANUM		
Ohia (Metrosideros collina)	Hawaii Nat'l Park, Hawaii	Numerous in soil around declining trees.

CITRUS EXPERIMENT STATION, UNIVERSITY OF CALIFORNIA

CLADOSPORIUM AECIDIICOLA THUEM. AND TUBERCULINA PERSICINA (DITM.) SACC. ASSOCIATED WITH PUCCINIA CONSPICUA (ARTH.) MAINS ON HELENIUM HOOPESII A. GRAY IN ARIZONA

Paul D. Keener

SUMMARY

A new rust host, Puccinia conspicua (Arth.) Mains on Helenium hoopesii A. Gray for the hyperparasite, Cladosporium aecidiicola Thuem., is reported herein. This is one of the few reports for this species of Cladosporium in the United States.

Also associated with the same rust was Tuberculina persicina (Ditm.) Sacc., which was present in the same rust sori with C. aecidiicola or in different sori.

Reports of the occurrence of Cladosporium aecidiicola Thuem. with species of rust fungi in North America are few. On the other hand, C. aecidiicola has been considered a fairly common hyperparasite of rusts on the continent of Europe, as well as in the region of the Mediterranean (5, 7, 8). Hassebrauk (4) reports that although he and his co-workers are conducting extensive investigations of several rust parasities in Germany, they have not encountered C. aecidiicola.

The existence of a specimen of C. aecidiicola associated with Colesporium ribicola Arth. (= C. jonesii (Peck) Arth.) was called to the attention of the writer by a staff member of the Plant Disease Survey, United States Department of Agriculture, Plant Industry Station, Beltsville, Maryland (Correspondence with Miss Muriel O'Brien). Additional specimens for study were made available through the courtesy of J. A. Stevenson, Curator, National Fungus Collections, Horticultural Crops Research Branch, Beltsville, and Dr. George B. Cummins, Associate Botanist, Department of Botany and Plant Pathology, Purdue Unviersity, LaFayette, Indiana. In the case of the latter material, Cladosporium aecidiicola was found in the telial sori of Colesporium crowellii Cummins on Pinus edulis Englm. The material referred to by Cummins in 1938 (3), was collected by Ivan Crowell at Cloudcroft, Otero County, New Mexico on July 3, 1937. The same hyperparasite was observed in the telial sori of the same rust on the same Gymnosperm host in all of the specimens sent by J. A. Stevenson (See Beltsville collections F. P. 3371 (which is apparently a combination of material from several collections from various locations), 11820, 24229, 25434, 46767 and an unnumbered collection by Bethel from Trimble Hot Springs, Colorado made on June 23, 1918). The collection F. P. 24229 from New Mexico includes some notations among which was "On some of these tongues and lesions there is a cladosporial growth but I think it is secondary". Uncertainty exists as to the authority for these remarks although they probably originated with C. Heinrich, the collector, rather than with G. G. Hedgcock who made the determination.

One other notation apparently dealing with C. aecidiicola Thuem., as a rust parasite in North America, was made by Smith (9). Smith stated "There occurs very abundantly in California a rust parasite which has not been previously recorded or seen by the writer in the Eastern States". Smith asserted his belief that the parasite was Cladosporium herbarum Link. The fungus was associated with Puccinia asparagi DC. This report (9) illustrates the rust parasite (p. 93) as well as parasitized rust spores.

In general, the occurrence of foliicolous or similar fungi in Arizona is rather sporadic because of the unusually dry atmosphere and other adverse conditions prevailing through most of the year. In October 1952, collections of a dematiaceous fungus growing on the leaves of Helenium hoopesii A. Gray (= Dugaldea hoopesii (Gray) Rydb., in Arthur's "Manual of the Rusts in United States and Canada", 1934), as well as in the aecial sori of rust (Puccinia conspicua (Arth.) Mains) on these leaves, were made in the area known locally as "Upper Sabino Canyon" in the Santa Catalina Mountains northeast of Tucson, Pima County. The superficial mycelium of the rust-inhabiting fungus was olivaceous-green to dark-brown in color. The massed hyphae were wooly. The dark color of the parasitized rust sori made them easily distinguishable from the light-colored hues of the non-inhabited ones (Fig. 1). In addition, the non-parasitized aecia were not wooly and possessed well-defined peridial cells. Sections of the material consisting of parasitized rust sori and examined after staining with Orseillin BB in Sartory's solution (1) or unstained, disclosed typical dematiaceous conidiophores and conidia. The morphological features of the hyperparsite agree with those recorded for Cladosporium aecidiicola in Rabenhorst (6) and in Hulea (5). In many instances, rust spores and peridial cells were found which had the dark-colored dematiaceous hyphae either in intimate contact or penetrating

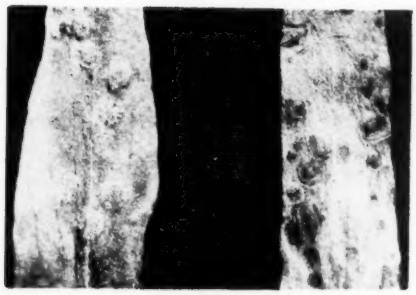

FIGURE 1. Aecial sori of Puccinia conspicua (Arth.) Mains on leaves of Helenium hoopesii A. Gray. At left, non-parasitized sori. At right: dark-colored areas occupied by aecial sori parasitized by Cladosporium aecidiicola Thuem. and Tuberculina persicina (Ditm.) Sacc.

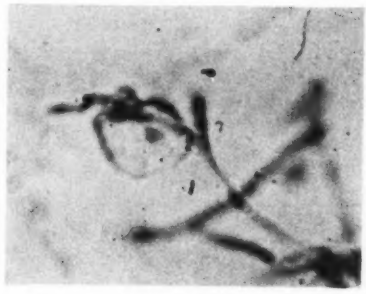

FIGURE 2. Rust peridial cell in contact with mycelium of C. aecidiicola. Photomicrograph, X about 727.5.

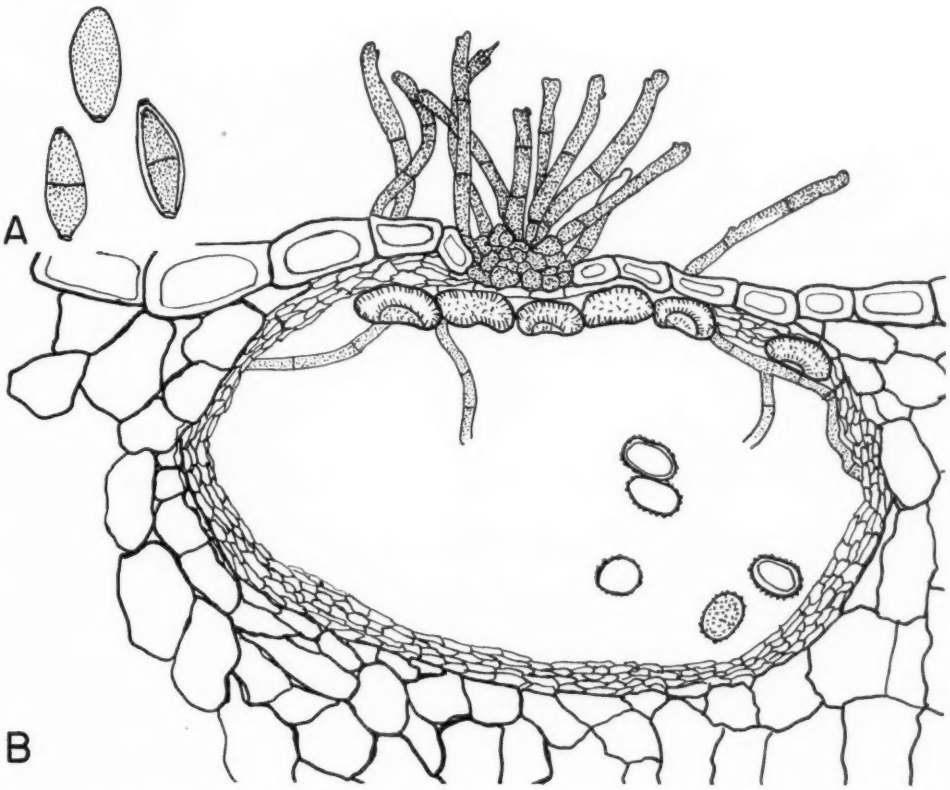

FIGURE 3. Schematic representation of C. aecidiicola on Puccinia conspicua on Helenium hoopesii. A. Spores of the hyperparasite, X about 727.5. B. Section through an aecium showing conidiophores of the hyperparasite in relation to rust, about X about 161.25.

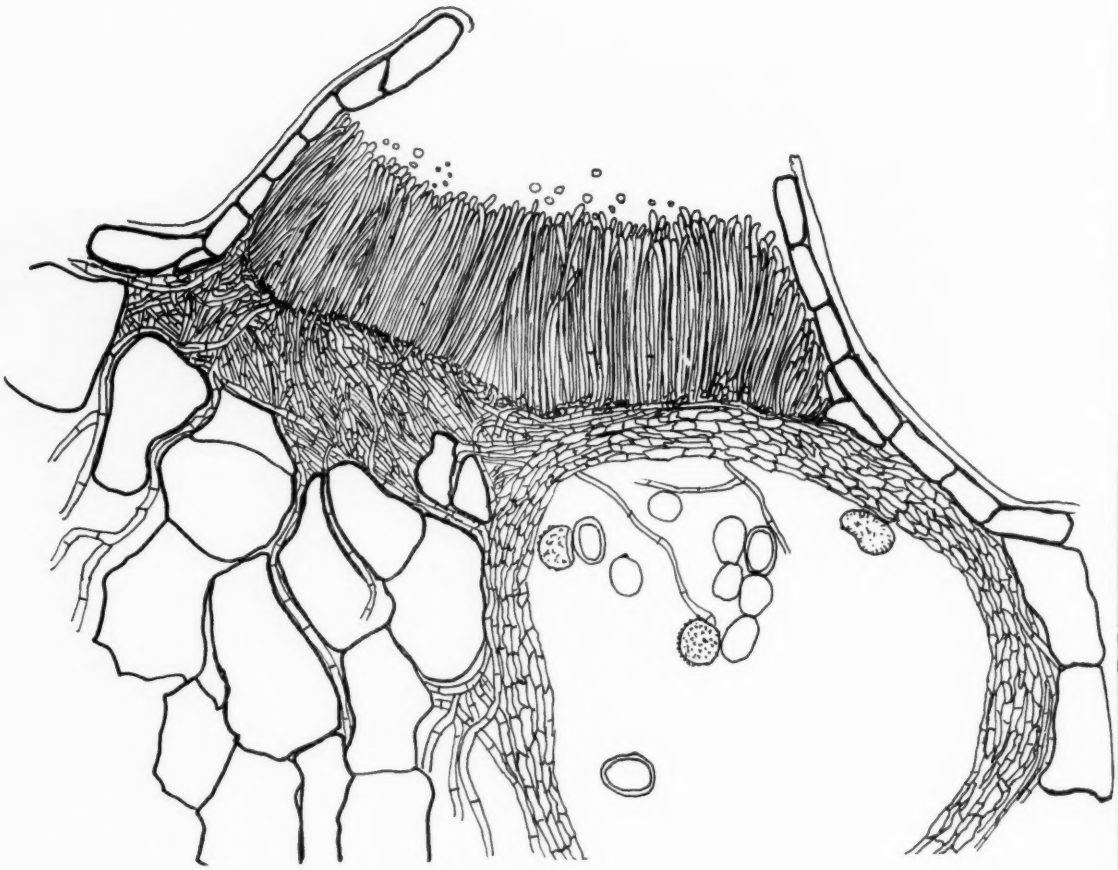

FIGURE 4. Schematic representation of a section through an aecium of Puccinia conspicua parasitized by Tuberculina persicina (Ditm.) Sacc. X about 161.25.

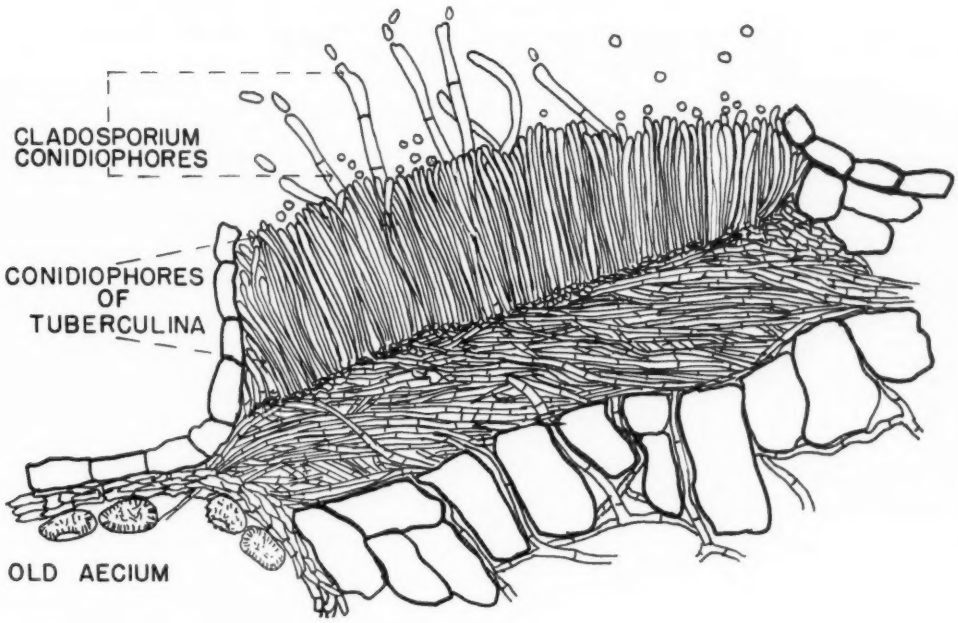

FIGURE 5. Schematic drawing of an area near an old aecium of Puccinia conspicua, overgrown with both Cladosporium aecidiicola and Tuberculina persicina. X about 161.25.

into them (Fig. 2). In some cases, aecia of the rust were observed to be entirely devoid of spores and other rust elements. Conidiophores and conidia of the hyperparasite were observed in abundance on or in close proximity to such empty structures (Fig. 3).

Another hyperparasite of rusts, Tuberculina persicina (Ditm.) Sacc., was also found associated with both pycnia and aecia of P. conspicua on H. hoopesii. In some instances, Cladosporium was present alone (Fig. 3); in others only Tuberculina (Fig. 4). Both of the hyperparasites were sometimes present together, on or in close proximity to the same aecial sorus of the rust (Fig. 5).

Recently, collections of C. aecidiicola have been made on Colesporium crowellii Cummins on Pinus edulis Engelm., at the South Rim of the Grand Canyon, Grand Canyon National Park, Coconino County, Arizona. In addition to C. aecidiicola, the Grand Canyon material of C. crowellii is also parasitized by a species of Darluca, belived to be D. filum (Biv.) Cast. In the latter instance, the position of the pycnidia of Darluca in the telial sori of the rust is so much at variance with all previous descriptions of the genus Darluca and of the species D. filum that further studies are in progress. The rust host itself is unique among the species of the genus Colesporium insofar as the telial stage occurs on the needles of coniferous plants. Usually, it is the pycnial and aecial stages which are found on needles of Gymnosperms.

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UNUSUAL RECORDS OF PLANT DISEASE OCCURRENCE

POWDERY MILDEW ON ALMONDS

By Roderick Sprague

The presence of the conidial stage of apparently Sphaerotheca pannosa on an unknown variety of almond (Prunus amygdalus) at the Tree Fruit Experiment Station was brought to the attention of the writer in June by Orchard Manager, James F. Eakin. The fungus caused buff lesions, on the fruit, measuring up to 3/4 inches in diameter. While the conidia were found in abundance on the fruits, there were no lesions on the leaves, at least not when last examined in mid-July. The tree was sprayed with 1/2 lb. Karathane in 100 gallons of water on June 29. The mildew was checked from further spread and there was no real injury to the leaves from the Karathane. Since we have experienced shot-holing in peaches even at the 1/2 lb. rate with Karathane, we were surprised to find no serious injury on the related almond. Karathane, incidently, is proving very effective as a control of apple powdery mildew (Podosphaera leucotricha). Powdery mildew on almond must be uncommon. We could find no mildew on a closely planted hedge-like row of almonds in E. L. Reeves' plots of the Columbia View plots (near Orondo) nor has Mr. Reeves seen mildew on almonds during the past quarter century. No reports of almond mildew from the United States are available. An examination of the pages of Review of Applied Mycology for the past 26 years discloses one report of S. pannosa on almonds from Malta (De Nardo, Rept. Dept. Agric. Malta 1936-37 pp. 40-43, 1938, see R.A.M. 16, p. 589. Sept. 1938). There is also a report of Phyllactinia salmonii (P. corylea) on almonds from India (Asghar, India J. Agric. Sci. 10 p. 96-97, 1940, see R.A.M. 19 p. 549, 1940).

WSC TREE FRUIT EXPERIMENT STATION, WENATCHEE, WASHINGTON

PRESENCE OF PIRICULARIA ORYZAE ON SUGAR CANE IN COSTA RICA

By Lucy Hastings de Gutiérrez

In 1951, a severe infection of Piricularia oryzae was recorded in an experimental planting of rice grown in the grounds of the Inter-American Institute of Agricultural Sciences in Turrialba, Costa Rica, C. A. The area was adjacent to a sugar cane field and had not been grown to rice for at least five years. The rice seed had been treated with ethyl mercury phosphate; no evidence of seed-borne infection was noted. A search for nearby hosts of P. oryzae was made and the fungus observed and isolated from sugar cane only. In 1953, in another area, also in Turrialba, rice tests bordered on two sides by sugar cane were again severely infected by P. oryzae. The organism was reisolated from the sugar cane and cross inoculations successfully carried out. The rice field (5460 M^2) showed very general heavy infection but no apparent trend of infection from the direction of the sugar cane could be detected. However, wind direction was erratic (most of the time a weather vane installed in the field was circling its pole), and prevailing weather conditions conducive to rapid and severe epiphytotic. It is of interest to note the presence of P. oryzae on sugar cane and it is felt that more study of the incidence of this organism on cane is needed.

INTER AMERICAN INSTITUTE OF AGRICULTURAL SCIENCES, TURRIALBA, COSTA RICA

OATS BLUE DWARF AND RED LEAF IN KANSAS

By W. H. Sill, Jr., C. L. King, and Earl D. Hansing

For several years blue dwarf and red leaf have been seen in Kansas oat fields. During the past four years the complex was more prevalent in 1951 and 1954. In 1954 it was present as scattered plants in most fields examined throughout the oat growing area and in a few fields possibly 5 percent or more of the plants were affected. In general losses have been slight but potentially this disease complex must be considered a threat to oats production in Kansas. It definitely appears to be on the increase. Based only upon field observations varieties Clinton, Nemaha, and Cherokee appear somewhat more susceptible than Mo. 0-205 and Kanota.

DEPARTMENT OF BOTANY AND PLANT PATHOLOGY AND DIVISION OF EXTENSION, KANSAS STATE COLLEGE, MANHATTAN, KANSAS

OUTBREAK OF FRAXINUS RUST IN MASSACHUSETTS

By Donald P. Limber

Fraxinus rust (Puccinia peridermiospora) is appearing in epiphytotic form in Massachusetts, extending from the coast to about 30 miles inland. All Fraxinus species in this area will soon be completely defoliated.

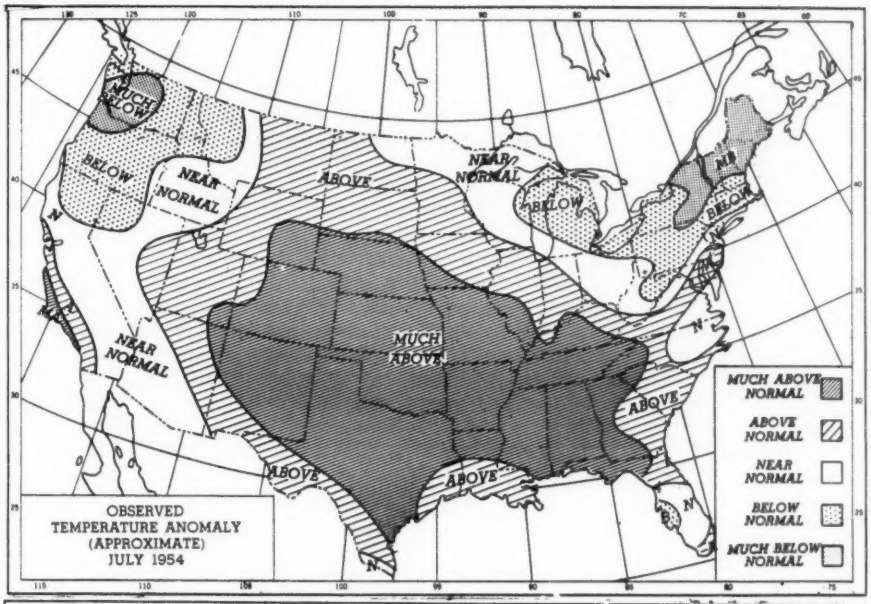
PLANT QUARANTINE BRANCH, HOBOKEN, NEW JERSEY

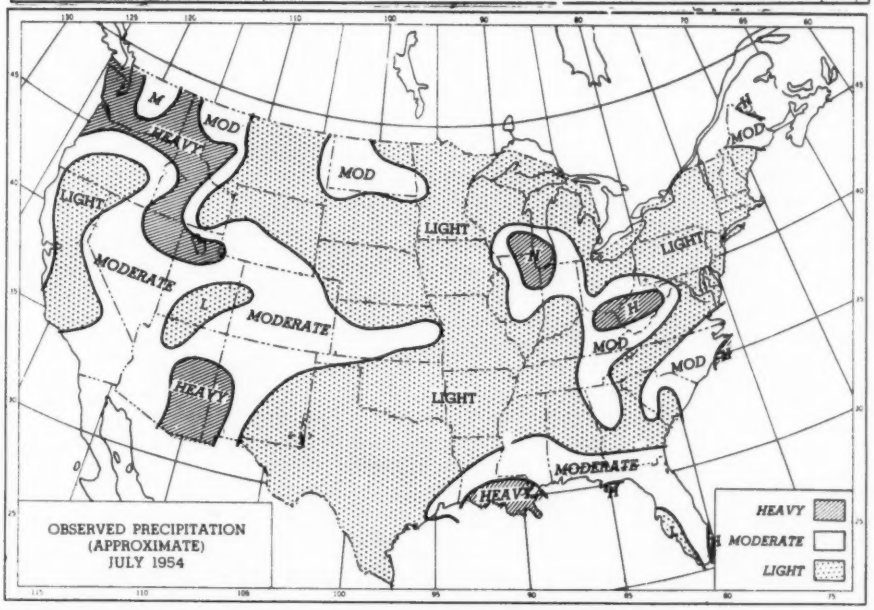
ANNOUNCEMENT: UNIFORM SYSTEM IN CODING BIOLOGICAL TAXONOMIC ENTITIES

A preliminary meeting was held recently to explore the possibility or advisability of developing a uniform system for use in coding biological taxonomic entities. Participants at this exploratory meeting were from the Library of Congress, the United States Department of Agriculture, the Smithsonian Institution, and the Chemical-Biological Coordination Center of the National Research Council.

It is known that several laboratories are entering the results of their experiments on machine or hand-sort punch cards and that at least a few are listing the species of plants or animals tested by means of a code on these punch cards. In order to facilitate the exchange of information between various laboratories, it would seem to be highly desirable for these research groups to use a uniform taxonomy coding system. If the need or usefulness of uniformity is confirmed by sufficient biologists, a start on the formation of a standardized code should be made as soon as possible so that the conversion from individual codes can be accomplished with a minimum of effort.

The interested persons who have been informally discussing the project do not want to set plans in motion for the actual codification unless there is a real or potential need for it. Our immediate problem, therefore, is to determine what areas of biology could be usefully served by a standard taxonomic code. We are, therefore, requesting that those who have worked out or adopted a system for coding taxonomic entities, or who may be conducting work which might benefit from such codification, submit their opinions concerning a standardized biological taxonomy code. Letters should be addressed to: Dr. G. Congdon Wood, Chemical-Biological Coordination Center, National Research Council, 2101 Constitution Avenue, N. W., Washington 25, D. C.





The terms used in the accompanying maps, which define the ranges of temperature and precipitation, are numerical class limits. These are based on a statistical analysis of past records through which is determined the normal frequency of occurrence of temperatures and precipitation at various times of the year for different locations. For temperature the classes above, below, and near normal are so defined that they each normally occur one-fourth of the time; much above and much below normal, one-eighth of the time. Precipitation is depicted in terms of light, moderate, and heavy, each class normally occurring one-third of the time and thereby having equal probability of occurrence. These maps graphically represent only the general trends and give the country's weather picture at a glance. For quantitative studies, where monthly mean temperatures and actual precipitation records are needed for a given time and place, other publications of the Weather Bureau should be consulted. P. R. M.